Preventative Maintenance Plan

for

Northern States Power Company, a Wisconsin Corporation,

d/b/a Xcel Energy

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1. Overview

The 2003 Preventative Maintenance Plan for Northern States Power Company, a Wisconsin Corporation, d/b/a Xcel Energy, (hereafter Xcel Energy) is contained within this document. This document will clearly explain the appropriate inspections and maintenance cycles, inspection methods, criteria for condition rating, and the corrective action schedule. Below are a series of tables that will outline the present practices for substation preventative maintenance for both the transmission and distribution substations. Also included are the transmission line and distribution line maintenance practices.

1.1. Distribution Substation and Line Maintenance Activities

The Inspection Schedule for all distribution substations, related equipment, and distribution lines can be found in Table 1 and Table 2. These tables define the maintenance activities and present work intervals.

Distribution Substation Maintenance

Activities	Intervals
Battery Condition Assessment	Yearly (Spring)
Battery Inspection	Yearly (Fall)
Transformer Condition Assessment (1/6 of total transformers in WI)	Every 6 years
Transformer oil testing - oil testing for all transformers not receiving the condition assessment	Yearly
LTC Inspections (1/6 of total LTCs in WI)	Every 6 years
Breaker Condition Assessments (1/6 of total breakers in WI)	Every 6 years
Regulator Condition Assessments (1/6 of total Regulators in WI)	Every 3 years
Substation Condition Assessments	Yearly
Substation Infrared Condition Assessments	Yearly
Relay System Condition Assessment (1/6 of total in I)	Every 6 years

Table 1

Distribution Line Maintenance

Activities	Intervals
Auto-transfer switchgear maintenance	Yearly
Field regulator condition assessment	Every 3 years
3 phase field recloser maintenance	Every 9 years
1 phase field reclosers maintenance	Every 9 years for Reclosers serving more than 100 customers
Infrared inspection of normal overload feeders	Yearly for feeders with projected overloads while in normal configuration
Infrared inspection of 1st contingency feeder with 150% overload	Yearly for feeders at risk
Network protectors	18 month cycle of inspection for dust-proof type; 36 month cycle of inspection for submersibles

Table 2

1.2. Transmission Substation and Line Maintenance Activities

Tables 3 and Table 5 contain the inspection schedules for transmission substations and related equipment, and transmission lines respectively. Table 4 provides information on the description of activities for each equipment type and the intervals for the inspections.

Inspection Schedule for Transmission Substation Equipment

Activity	Intervals for Inspections
Battery - Condition Assessment - Spring	Yearly
Battery – Inspection – Fall	Yearly
Substation Infrared Assessments	Yearly
Transmission Line Relay and Carrier system testing – Bulk Transmission Lines	Every two years
Substation Condition Assessment	Yearly
Transformer oil testing	Yearly
Transformer Electric Test	Every six years
Transformer LTC Condition Assessments	Every six years
Transformer Relay Test	Every six years
Circuit Breaker -Condition Assessment	Every six years

Table 3

Xcel Energy owns, operates and maintains 23kv, 34.5kv, 69kv, 115kv, 161kv and 345kv overhead line facilities as well as 69kv underground transmission facilities. Table 4 lists the miles of transmission lines by voltage class. These numbers determine the numbers of line miles to fly, inspect wood poles, and or foot patrol described in Table 5.

Transmission Line Miles in WI

Voltage (kV)	Number of line miles
345	164
161	345
115	448
88	73
69	1052
34.5 kV (sub-transmission)	327
TOTAL	**2409**

Table 4

Table 5 provides information on the type of patrol for the bulk transmission system versus the load serving transmission system.

Inspection Schedule for Transmission Lines

Types of Patrols	Bulk System	Load Serving
Fixed Wing	Monthly	Quarterly
Helicopter	Yearly	Yearly
Ground Patrol	Yearly	Yearly
Wood Pole Inspection	Every 12 years	Every 12 years
Climbing Inspection	As Needed	As Needed
Vegetation	As Needed	As Needed
Infrared	As Needed	As Needed

Table 5

- Fixed wing patrols are performed at the intervals shown. Emergency patrols are performed on an as needed basis, following breaker operations.
- A helicopter patrol is performed at the interval shown at a reduced flying speed to give a more detailed inspection of the transmission system.
- Ground patrols are performed on those portions of the transmission system that cannot be flown by fixed wing or helicopter.
- Wood pole inspection is performed on approximately $1/12^{th}$ of the transmission system yearly.
- Climbing, vegetation, and infrared inspections are performed in response to known hardware or structural problems.

1.2.1. Transmission Line Maintenance Work Plan

Transmission Line Maintenance Work

1. Perform emergency repairs as needed.
2. Track all anomalies found on patrols or inspections.
3. Schedule maintenance work as indicated by priority of need.
4. Track all completed repairs.

Transmission Right-of-Way Maintenance

1. Perform emergency trimming or clearing as needed.
2. Perform cycle trimming or clearing of system lines.

Transmission Pole and Tower Maintenance

1. Reinforce or replace wood poles as indicated by inspections.
2. Monitor or install preservative in poles as indicated by inspections.
3. Repair or recondition steel poles and towers as indicated by patrols or inspections.

1.3 Substation Corrective Maintenance Priority Scheme

In addition to the Preventative Maintenance, Construction Operating and Maintenance (COM North) receives requests for service from the control center, field crews, engineering, operators, and others. These requests are logged, discussed, and prioritized on a daily basis. Table 6 provides a methodology to prioritize the daily request for information for COM North and provides a mechanism to track the status of a particular request for service. The corrective maintenance requests also follow the guidelines in table 6. Consideration is given to ability to outage a piece of equipment for repair, lead-time for parts, resource availability, and critical nature of the repair.

Substation Priority Scheme

Priority Number	Descriptions
1	Items that should be commenced immediately
2	Items that should be completed within two weeks
3	Items that should be completed within three months
4	Items that should be completed within one year

Table 6

Documents containing the methods of inspection, instructions for the inspectors, and the condition rating criteria for each piece of equipment, can be found within Tab 2 through Tab 14.

Field inspector and crew records are forwarded to the manager of Construction Operations & Maintenance in Eau Claire, Wisconsin. The manager reviews and prioritizes the corrective work in accordance with Table 6. Records are then filed in a central filling system located at the Eau Claire, Wisconsin offices.

Infrared Surveys

1. Purpose

Conduct infrared surveys on the Electric Delivery System to find hot spot conditions and correct the problem before it causes an outage.

2. Scope

Infrared survey sites include Distribution and Transmission Substations (all equipment, buss, and connections) and the Distribution System (Overhead – connections and equipment, Underground – padmount switchgear, capacitors, and transformers.

Surveys should be completed during off-peak, (spring or fall) so that repairs can be made prior to peak. (It is usually difficult to obtain outages to equipment for repairs during peak times.)

Infrared Survey

Appendix A : Substations

1. Task

Conduct a yearly preventative maintenance infrared survey of all substations. All buss, equipment, and connections are to be surveyed with an Electronic Imaging, Infrared Camera

2. Condition

Conduct preventative maintenance infrared surveys of substations to identify potential problems due to hot spots.

Maintenance and construction departments will work to correct potential problems before equipment is damaged and/or outages are caused.

3. Guideline

Guidelines to repair hotspots within a range of temperatures above ambient are found in Table 1. Ambient is defined as the temperature of like or adjacent equipment.

Temp above Ambient (degrees)	Action Required
0 – 50 F (0 – 28 C)	Re-check spot in 6 months*
51 – 120 F (29 – 67 C)	Repair within 1 month
121 F + (68 C +)	Repair or take out of service within one business day

Table 1

* Substation Transformers with hot spots of 20 degrees F or greater above ambient should be fixed As Soon As Possible (one week or less).

Infrared Survey

Appendix B : Distribution Feeders

1. Task

Conduct Preventative Maintenance infrared survey of Distribution feeders.
All equipment and connections are to be surveyed with an Electronic Imaging, Infrared Camera

2. Condition

Conduct preventative maintenance infrared surveys of distribution feeders that are identified with normal overload conditions or as worst performing feeders, in order to identify potential problems due to hot spots.

Mainline feeders – Overhead and underground, including all equipment (such as switchgear, capbanks, transformers, reclosers, etc.) and connections.

Maintenance and construction departments will work to correct potential problems before equipment is damaged and/or outages are caused.

3. Guideline

Guidelines to repair hotspots within a range of temperatures above ambient are found in Table 1. Ambient is defined as the temperature of like or adjacent equipment.

Temp above Ambient (degrees)	Action Required
0 – 50 F (0 – 28 C)	Re-check spot within one year
51 – 120 F (29 – 67 C)	Repair within 3 months
121 F + (68 C +)	Repair or take out of service within one business day

Table 1

Substation In-Service Inspection

1. Purpose

This procedure is for the routine In-Service inspection of Xcel Energy substations.

2. Definitions

2.1. **Inspection** includes the following:
- 2.1.1. Cleaning devices.
- 2.1.2. Testing as required.
- 2.1.3. Repairing or Correcting sub-standard conditions where possible.
- 2.1.4. Noting "as-left" conditions that require further attention.
- 2.1.5. Recording "as found" and "as left" conditions.

2.2. **Maintenance Provider Technician**
That individual, trained and qualified in accordance with appropriate testing instructions and procedures, who has been designated by the Supervisor as having the responsibility for the correct performance of the work required by this procedure.

3. Equipment Needed

3.1. A properly stocked Maintenance truck
3.2. Inspection Forms

4. References

4.1. Manufacturer's Instruction Book for each piece of equipment
4.2. Substation One-line diagram

5. Procedure

5.1. Precautions

5.1.1. Maintenance provider personnel shall take necessary precautions to prevent accidental contact with high voltage equipment as per the Xcel Energy **Safety Manual**.

5.2. Instructions

NOTE: Use pen in completing all forms. Results of the following steps shall be documented on Inspection Report Pages. Each step of these instructions shall be initialed prior to starting the next step.

5.2.1. **Maintenance Truck** - Before proceeding to an inspection site, check the truck for sufficient supplies per the In-Service Inspection Parts List for Trucks _____

5.2.2. Contact System Operator or Regional Dispatcher prior to inspection and inform them that you are in the substation performing maintenance. _____

5.2.3. **Electrical Apparatus** - Check each and every piece of apparatus in the yard and complete the appropriate Inspection List for each. Document As-Found and As-Left conditions on the Inspection Report. _____

5.2.4. **Check, Correct and/or document any irregularities found in the yard or control house.** _____

5.3. Close-out

5.3.1. Complete all **Inspection Forms.** Record all required information including work done and "As Found" conditions that may have prevented proper operation of the equipment. _____

5.3.2. Insure **all data forms** are completed and attached. _____

5.3.3. Reviewed by Engineer. _____

MISCELLANEOUS EQUIPMENT INSPECTION LIST

(attach as many sheets as necessary)

Substation _____

Electrical Apparatus - attach detailed inspection sheets as needed.

1) **Inform – Systems Operation, Trouble Foreman or Local Dispatch, that you are in the substation performing maintenance.**

1) Visually inspect general condition of equipment:

	Condition	Needs Attn.	Remarks
a) Cap banks (fuses, leaks etc.)	_____	_____	_____
b) MOD's (heaters, fuses, Thermostats, etc.)	_____	_____	_____
c) Insulators (chipped, broken or flashed)	_____	_____	_____
d) C.T.'s & P.T.'s (oil leaks, oil level)	_____	_____	_____
e) Disconnects (no arching, fully closed, etc)	_____	_____	_____
2) Visually inspect other Substation conditions:	_____	_____	_____
a) insulators, disconnects, station grounds, etc...	_____	_____	_____
b) Sample oil if due.	_____	_____	_____
3) Note any conditions requiring an outage to repair.	_____	_____	_____

Other Remarks or Comments

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

CREW MEMBERS _____ **DATE** _____

SUBSTATION IN-SERVICE INSPECTION

TRANSFORMERS AND LTC INSPECTION LIST

(attach as many sheets as necessary)

Substation _____
Transformer # _____
(For more detailed instructions see APP – 6.017.05)

1) **Inform – Systems Operation, Trouble Foreman or Local Dispatch, that you are in the substation performing maintenance.**

2) Visually inspect general condition of equipment:

	Condition	Needs Attn.	Remarks
a) Bushings (oil levels, broken etc.)	_____	_____	_____
b) oil levels (main tank and LTC)	_____	_____	_____
c) Control cabinet (fuses, heaters, thermostats etc.)	_____	_____	_____
d) Animal guards	_____	_____	_____
e) Grounding connections	_____	_____	_____
f) Is the TR schematic in the control cabinet?	_____	_____	_____
g) Oil leaks	_____	_____	_____
h) operate fans and pumps (lubricate)	_____	_____	_____
i) Change Nitrogen bottle if under 600 psi	_____	_____	_____
j) Check for leaks (using soap suds)	_____	_____	_____
k) Sample oil if due	_____	_____	_____
l) Note any conditions requiring an outage to repair	_____	_____	_____

Note any conditions requiring an outage to repair. Remove defective fans for repair.

Comments:

_____
_____
_____
_____
_____
_____
_____
_____

Complete inspection sheets and return to office.

SUBSTATION IN-SERVICE INSPECTION

VOLTAGE REGULATOR INSPECTION LIST

(attach as many sheets as necessary)

Substation _____
Regulator # _____

1) **Inform – Systems Operation, Trouble Foreman or Local Dispatch, that you are in the substation performing maintenance.**

2) Visually inspect general condition of equipment:

	Condition	Needs Attn.	Remarks
a) Bushings	_____	_____	_____
b) Oil Levels	_____	_____	_____
c) Oil Leaks	_____	_____	_____
d) Control Cabinet	_____	_____	_____
e) Grounding connections	_____	_____	_____
f) Animal guards	_____	_____	_____
2) Check fuses, heaters and thermostats.	_____	_____	_____
3) Tap Changer:			
a) Note number of operations	_____	_____	_____
b) Note operating range:	from _____ to _____	_____	_____
c) Currently on tap:	_____	_____	_____
d) Has the tap changer operated through neutral?	_____	_____	_____
e) Is the counter working?	_____	_____	_____
f) Oil Level (high, low, OK)	_____	_____	_____

Comments:

_____
_____
_____
_____
_____
_____
_____

Complete inspection sheets and return to office.

SUBSTATION IN-SERVICE INSPECTION

OIL CIRCUIT BREAKER INSPECTION LIST

(attach as many sheets as necessary)

Substation _____
Breaker # _____

1) **Inform – Systems Operation, Trouble Foreman or Local Dispatch, that you are in the substation performing maintenance.**

2) Visually inspect general condition of equipment:

	Condition	Needs Attn.	Remarks
a) Bushings (oil levels, broken etc.)			
b) Main tank (oil levels)			
c) Oil Leaks			
d) Grounding connections			
e) Animal guards			
f) Control Cabinet			
g) Is the BKR schematic in the control cabinet?			
3) Check fuses, heaters and thermostats.			
4) Compressor (as applicable)			
a) Note hours of run-time			
b) Check belt, oil level, check valve, and pulleys			
c) Oil leaks			
5) Mechanism			
a) Visually inspect general condition.			
b) Clean mechanism cabinet.			
c) Check fuses, heaters & thermostats.			
d) Pneumatic: Weather permitting: drain moisture from air tanks and check pressure switches.			
e) Hydraulic: Lower pressure, check pressure switches, and pre-charge.			

Comments:

_____

_____

_____

Complete inspection sheets and return to office.

SUBSTATION IN-SERVICE INSPECTION

GAS CIRCUIT BREAKER INSPECTION LIST

(attach as many sheets as necessary)

Substation _____
Breaker # _____

1) **Inform – Systems Operation, Trouble Foreman or Local Dispatch, that you are in the substation performing maintenance.**

2) Visually inspect general condition of equipment:

	Condition	Needs Attn.	Remarks
a) Bushings (oil levels, broken etc.)			
b) Main tank			
f) Animal guards			
c) Gas pressure (s)			
d) Grounding connections			
e) Control Cabinet			
f) Is the BKR schematic in the control cabinet?			
g) Note any conditions requiring an outage to repair.			
3) Check fuses, heaters and thermostats.			
4) Compressor (as applicable)			
a) Note hours of run-time			
b) Check belt, oil level, check valve, and pulleys			
c) Oil leaks			
5) Mechanism			
a) Visually inspect general condition.			
b) Clean mechanism cabinet.			
c) Check fuses, heaters & thermostats.			
d) Pneumatic: Weather permitting: drain moisture from air tanks and check pressure switches.			
e) Hydraulic: Lower pressure, check pressure switches, and pre-charge.			

Comments:

_____

_____

Complete inspection sheets and return to office.

SUBSTATION IN-SERVICE INSPECTION

IN-SERVICE INSPECTION PARTS LIST FOR TRUCKS

TRUCK # _____

EQUIPMENT NEEDED:

Stk.	Req.	Description	OK?
____	1 EA	1/2", 3/8", 1/4" Plugs for end of Ball Drain Valve	____
____	3 EA	1/2" Ball Check Drain Valve	____
____	3 EA	3/8" Ball Check Drain Valve	____
____	3 EA	1/4" Ball Check	____
____	50 EA	Tags for Safety Valve & Compressor	____
____	1 EA	5 Gallon 427 Oil	____
____	2 EA	5 Gallon Waste Container	____
		Safety Relief Valves:	
____	2 EA	290#	____
____	2 EA	175#	____
____	2 EA	150#	____
____	2 EA	100#	____
____	100 EA	In Service Inspection Forms.	____
____	6 EA	Gas-in-Oil Test Kits	____
____	1 EA	Extra Ohm Meter	____
____	25 FT	Belts and/or material to make ('make-a-belt")	____
____	misc.	Heater elements) (120 & 240volts AC, 50, 100, 250 & 350 watt)	____
____	misc.	Thermostats	____
		Connection Hardware & Tools	
____	1 box	½" x 1 ¾" aluminum bolts, stk # 01-5991 (100 bolts)	____
____	1 box	½" x 2 ¼" aluminum bolts, stk # 01-5992 (100 bolts)	____
____	1 box	½" x 3" aluminum bolts, stk # 01-5995 (100 bolts)	____
____	1 box	½" aluminum nuts, stk # 01-5995 (100 nuts)	____
____	1 EA	Stainless steel brush for aluminum hardware, stk # NS-4804	____
____	1 EA	2-pronged V-shaped wire brush, stk # NS-4808	____

Complete inspection sheets and return to office.

Substation Battery Maintenance

1. **Purpose**
   The purpose of this procedure is to provide general instructions for inspection and maintenance of Lead Acid Stationary Batteries in Substation.

2. **Definitions**
   2.1. **Battery Thermom**eter A special thermometer usually calibrated in (F°) with a linear scale designed to indicate specific gravity correction for cell temperature.

   2.2. **Cell-Corder Storage Battery Multi-meter** A special instrument used to record, and test a batteries cells for "Float Voltage", "Internal Cell Resistance", "Inter-Cell Connection Resistance", and record either manually or electronically a cells "Specific Gravity".

   2.3. **Constant Current Charge** A charge in which the current output of the charger is maintained at a constant value. Sometime this may be accomplished using two-rate charging.

   2.4. **Constant Potential Charge** A charge in which the potential (or voltage) at the output terminals of the battery charger is maintained at a constant value. (Also called Constant Voltage Charge).

   2.5. **Electrolyte** A conducting medium in which the flow of electric current takes place. The electrolyte in a lead-acid cell is a solution of sulfuric acid (H_2SO_4) and water. The electrolyte in a nickel-cadmium cell is a solution of potassium hydroxide (KOH) in water.

   2.6. **Flame-Arrestor Vent** A cell-venting device which prevents the propagation of an external flame into the cell. It is to be kept in place at the top of each cell for maintenance and charging. Also referred to as a "Safety Vent".

   2.7. **Gassing** Evolution of gas by one or more of the plates in a cell. Gassing may result from electrolysis of water into hydrogen and oxygen within a cell during charging (normally near the end of a charge), from overcharging, or from local action.

   2.8. **Equalize Voltage** The maximum voltage at which a battery is charged. The "equalize" voltage corrects voltage irregularities between cells by overcharging them.

   2.9. **Float Voltage** The minimum voltage at which the battery is maintained or charged.

   2.10. **Hydrometer** An electronic or syringe device used to measure the specific gravity or a battery cells electrolyte density and determine the cells' state of charge.

2.11. **Inter-cell connector** Lead plated rigid copper connector used to connect individual battery cells together, generally in series.

2.12. **Inter-cell connection resistance** The total electrical resistance of the connection between the terminals of two cells that are electrically connected to each other. Resistance is expressed in micro-ohms, and is measured by a micro-ohmsmeter or similar device.

2.13. **Internal impedance** The resistance of a cell to an alternating current of a specific frequency.

2.14. **Internal Resistance** The resistance of a cell to an electric current within a cell. See Cell-Corder multi-meter.

2.15. **Lead Selenium Battery Cells** A lead-acid cell with plates or grids made from a lead-antimony alloy to which selenium has been added. Charging characteristics are similar to Lead Calcium battery cells.

2.16. **Lead Antimony Battery Cells** A style of battery with Antimony grids which requires periodic "Equalizing" approximately every 30 to 90 days to bring the battery back to full capacity.

2.17. **Lead Calcium Battery Cells** A type of battery cell with calcium grids similar in appearance to the Lead Antimony type, which must be "Float Charged" at a higher voltage. These cells do not require periodic "Equalizing" when maintained at the proper voltage. However "Equalizing" shall be performed on this style of battery when scheduled maintenance is performed or when problems are encountered, requiring maintenance of the battery.

2.18. **Pilot Cell of Battery** One (1) or two (2) cells in a series battery string picked for monitoring purposes to indicate a battery's general state of charge or condition. The cell picked is usually the one in the string that has the lowest specific gravity or is picked at the discretion of the inspector for monitoring purposes.

2.19. **Post To Cover Seal** The seal between the post and the cover where the post penetrates the cover.

2.20. **Sealed or Absorbed Electrolyte Valve Regulated Lead Acid (V.R.L.A.) Battery Cells. Also known as Absorbed Glass Mat or A.G.M.** A completely sealed cell with no provisions to sample specific gravity or examine internal components. This type of cell is generally arrange in modules and must be "Float Charged" at a higher voltage. These cells do not require periodic "Equalizing" when maintained at the proper voltage. However "Equalizing" shall be performed on this style of battery

when scheduled maintenance is performed or when problems are encountered, requiring special maintenance.

2.21. Service Life The period of time during which a fully charged battery is capable of delivering at least a specified percentage of its rated capacity. For most lead-acid battery designs this percentage is 80 %. (Also called END OF LIFE or USEFUL LIFE).

2.22. Thermal Runaway A condition whereby a cell on charge or discharge will destroy itself through internal heat generation caused by high overcharge or over discharge current or other abusive condition such as high ambient temperature. All batteries generate heat due to electro-chemical reactions, however A.G.M. batteries are especially susceptible to this condition.

2.23. **Valve** A normally sealed mechanism which allows for the controlled escape of gasses from within a cell. See Absorbed electrolyte cell or V.R.L.A. (Valve Regulated Lead Acid) cells.

2.24. **"As Found"** Measurements made before any cleaning, adjusting, or repairing is done on a battery.

2.25. **"As Left"** Measurements made after cleaning, adjusting, and repairing have been completed on a battery.

2.26. **Maintenance Provider Technician** That individual, trained and qualified in accordance with appropriate Testing Instructions and procedures, who has been designated by the Maintenance Provider as having the responsibility for the correct performance of the work required by this procedure.

2.27. **Supervisor** The person designated with the responsibility to authorize the start of work activities.

3. Equipment Needed

3.1. The maintenance provider personnel shall assure that all instruments used are in good working condition, within calibration dates and shall display a current calibration sticker.

3.2. Battery cell specific gravity reading hydrometer (Syringe type) may be used, but first its accuracy shall be verified by comparing its reading with another hydrometer. Variances of ± 0.005 are acceptable.

3.3. Electronic specific density gravity meters, such as the Anton Paar type DMA-35 or the Alber Corp. Hydrostik, type DSG-30.

3.4. Alber Corp. Cell-corder type CLC-200 with firmware version 2.03, electronic data logging multi-meter.

3.5. Micro-ohms Meter Low Resistance Test Set, such as Alber Corp. RT3-100L, 100 amps.

3.6. AVO International Battery Impedance Test Set, such as the M-Bite or E-Bite system.

3.7. Digital multi-meter, 3 1/2 digit model.

3.8. The following equipment is recommended to perform this maintenance:

NOTE: Most equipment is available from Curtin Matheson Scientific Inc., Telephone # 934-1793 or battery vendors, such as H.M. Cragg Co., Telephone # 884-7775.

3.8.1. Pressurized spill gun acid neutralizer, such as spill-X-A model SC-30-A.

3.8.2. Two (2), five (5) gallon carboy water bottles filled with approved demineralized water. Water can be obtained from the battery shop: cat.#031-682, carboy bottles with caps.

3.8.3. Twenty-five (25) lbs of bicarbonate of soda, available from Hawkins Chemical Inc.

3.8.4. Two (2) specific gravity hydrometers, type C&D Co., part no. PL538, range 1.170 - 1.240. Preferred use is Electronic Hydrometers

3.8.5. Battery type thermometers, type C&D Co., part no. PL645 or Electronic Thermometer. See Instruments and Calibration section.

3.8.6. Calibrated torque wrench, 3/8 " drive, 5 to 200 inch pounds.

3.8.7. Battery cell filling container for adding water to individual cells or electric watering pump cart, 8 gallon, type Model CRT-2A, with watering gun type S.

3.8.8. Various hand tools, wrenches, 3/8" socket set drive, rags, etc.

3.8.9. Two (2) pails, polyethylene type, cat. no. 040-253.

3.8.10. Three (3) sets of rubber neoprene gloves, light weight type, size 9, cat. no. 200-899.

3.8.11. Two (2) light weight black rubberized cloth aprons, 36" to 46", cat. no. 021-733.

3.8.12. Twelve (12) buffered eyewash solutions, such as North Sterile Isotonic bottles, no. 12-60-37.

4. References

4.1. **Alcad,** Lead Acid Battery Operating Instructions.

4.2. **C & D Co.,** Standby Battery Flooded Cell Installation and Operating Instructions, No. 12-800.

4.3. **C & D Co Liberty Series 1000,** Valve Regulated Installation and Operating Instructions, No RS-990.

4.4. **C & D Co Liberty Series 2000,** Valve Regulated Installation and Operating Instructions, No RS-991.

4.5. **YUASA Exide,** Instructions for Installation and Operating Stationary Battery, section 58.00.

4.6.**G.N.B.,** Installation and Operating Instructions for Absolyte 11P Batteries, section 92.61.

4.7. **G.N.B.,** Stationary Battery Installation and Operating Instruction, section 8-05.

4.8. **Johnson Controls (Globe),** Installation and Operating Instructions for Stationary Lead Acid Battery Cells.

4.9. **Varta**, Stationary Battery Installation and Operating Instructions, section 16-202.

5. Procedure

5.1. Precautions

5.1.1. Before touching a battery cell, static electricity should be discharged from the body by first touching station ground or battery grounded rack.

5.1.2. Battery cells connected in series may have high potentials, thus producing a human shock hazard. Therefore, the battery and station ground should not be touched or leaned on at the same time.

5.1.3. Arcing, smoking and open flame are prohibited within the battery room and vicinity.

5.1.4. Metal tool handles used for tightening battery cell connector bolts shall be insulated.

5.1.5. Safety equipment is to be worn by all personnel in the battery area. Safety glasses shall be worn at all times. Rubber gloves and rubber aprons should be worn when handling acid or moving battery cells around.

5.1.6. Do not open battery circuits, jumper cells or connect any load producing equipment to a battery or its cells.

5.1.7. Be aware of the high voltage potentials within the battery charger while taking readings or otherwise checking its operations.

5.1.8. Use approved demineralized water when adding water to a battery cell.

5.1.9. **WARNING:** Adding contaminated water, metal or other impurities to battery cells will cause damage to the cell.

5.1.10. Do not over tighten cell connections; this will cause damage to battery posts and/or seals and attribute to battery failure, and high connection resistance's.

5.1.11. Avoid contact with the battery electrolyte (Sulfuric Acid) or Nickel Cadmium (Potassium Hydroxide) solutions. Contact will cause severe burns to exposed skin and damage to clothing. For skin - if contacts occur, immediately flush skin with water and then flush clothing - immediately remove the soiled item and flush with water then neutralizer solution.

5.1.12. Do not use solvents or chemicals to clean batteries.

5.1.13. Do not over fill battery cells when adding demineralized water. Electrolyte levels for each cell must be at or within the indicator lines marked on each cell. **Note:** Keep safety vents (Flame Arresters) in place on cells whenever possible.

5.2. Instructions

NOTE: Use pen in completing all forms. Results of the following steps shall be documented on the forms attached. Each step of these instructions shall be initialed prior to starting the next step.

NOTE: The following steps (5.2.4, 5.2.5, 5.2.8, 5.2.10, and 5.2.14) may be N/A in this procedure, and all data can be recorded using the Albercorp Cell-Corder model CLC-200. See Definitions section.

5.2.1. Verify Supervisor has authorized work to start. _____

5.2.2. All initials shall be identified below:

Initial Print Name

_____ _____
_____ _____
_____ _____
_____ _____

5.2.3. Check station battery charger for correct "FLOAT" and "EQUALIZE" voltage operation. Refer to **Table I** in **Appendix A** for correct voltage settings of types and number of cells to be work on. _____

5.2.4. Remove all battery cell filler dust caps and record the electrolyte temperature of at least three (3) cells in the battery. _____

Cell-corder

5.2.5. Measure and record every cell specific gravity, using the station hydrometer, or one known to be accurate as described in the instrument and calibration section. Correct specific gravity readings for temperature variations back to 77° F by using the following rule:

1. For every 3° F above 77° F, add 0.001 to the specific gravity reading.

2. For every 3° F below 77° F, subtract 0.001 to the specific gravity reading. _____

Cell-corder

5.2.6. Check battery cell electrolyte level. **NOTE:** The approximate level in relation to the two indication lines on each cell. **Record:** Any cells which have excessively low or high levels, as this will affect the specific gravity readings. _____

5.2.7. If electrolyte level is more than 1/2" below the high line marked on the cells, add sufficient demineralized water to bring the level back to this line. Use approved water or demineralized water. Replace all battery filler caps previously removed. _____

NOTE: Electrolyte level is measured from the full level mark on C&D, Varta and GNB batteries and between the two level marks on YUASA Exide type cells.

5.2.8. With battery charger still on "FLOAT" voltage, record individual cell voltage readings and charger output current, as indicated by its ammeter on **Stationary Battery Report in Appendix A** Verify battery charger DC output meter reads correctly by checking battery voltage at battery DC bus or terminals with digital meter. If necessary readjust the voltmeter on the charger to indicate correct voltage if necessary. _____

Cell-corder

5.2.9. Place charger on "EQUALIZE" charge. Observe charger voltmeter and ammeter. Charger should raise battery voltage to "EQUALIZE" voltage. Refer to **Table I** on **Appendix A** for correct voltage and settings. _____

5.2.10. Allow charger to stabilize battery voltage and current for 15 - 30 minutes. Then record all cell "EQUALIZING" voltages on **Stationary Battery Report in Appendix A.** _____

Cell-corder

5.2.11. Switch charger back to its float voltage setting. _____

5.2.12. Check battery polarities to station ground for any voltage indications, or grounds. Record if any in "comments section". _____

5.2.13. Physically examine all battery cells from both the front and back side. Observe each cell for the following abnormalities and circle any items observed exhibiting these abnormalities. Record any observations in the "comment section". _____

1. Broken or deteriorated plate elements to its bus bar or comb connection areas within each cell thru its container if visible. _____

2. Discolored positive or negative plates. Compare to adjacent cells. Examine for signs of Copper Contamination's, as indicated by reddish/brown negative plates or discolored electrolyte. _____

3. Check for electrolyte leakage, cracks in cell containers, or seals between posts and cover, cover to jar seals and examine underside of cells (container bottoms) if accessible. _____

4. Abnormal electrolyte color or levels. _____

5. Abnormal sediment color or sediment levels below negative, and positive plates. _____

6. Observe cell plates for excessive expansion, as indicated by cracks or bulges in the cell container and its cover. _____

7. Suspended or floating objects in electrolyte. _____

8. List any other observed abnormalities in comment section. _____

5.2.14. Examine inter-cell connectors, and connections at cell posts for corrosion and tightness. Use a calibrated torque wrench to check the torque of each inter-cell connector to the values noted in **Table II** in **Appendix A**. Complete inter-cell, inter-rack or step connection resistance tests using a micro-ohmmeter and record these values on **Intercell Connection Test Report in Appendix A**. Designate with an asterisk those values for cable connections or connections other than standard inter-cell rigid connectors. _____

Cell-corder

5.2.15. If the battery is dirty or wet with acid, wash with a water-moistened cloth and/or an approved neutralizing agent. _____

NOTE: A 6% clear Ammonia and water solution may be used on some cells to clean the battery, this solution should be mixed to the consistency of household cleaning solutions. Do not use on polycarbonate containers or where ventilation is a problem.

WARNING: Do not use **HYDROCARBON** agents (oil distillates) or **ALKALINE** cleaners. These products may cause the jar containers to crack and/or craze. Neutralize any electrolyte

spills with distilled water or diluted **BICARBONATE of BAKING SODA** in mixture of 1 pound soda to 1 gallon of distilled water. Clean or wash polycarbonate containers with clear water only.

5.2.16. Select a new pilot cell for monitoring purposes. The pilot cell is generally the lowest specific gravity cell in the battery. However, the cell picked may be any cell which at the discretion of the inspector, indicates it should be monitored more closely. _____

5.2.17. Mark the pilot cell denoting the date of this inspection and record the identification of the pilot cell on the attached data sheet. _____

5.3. <u>Close-out</u>

5.3.1. Assure **all data forms** are completed and attached. _____

5.3.2. When the above has been completed, return this completed procedure to the Supervisor. _____

5.3.3. Reviewed by Supervisor. _____

5.3.4. Reviewed by Engineer. _____

REVISION HISTORY

Revision	Comments
1	

STATIONARY BATTERY REPORT

ROUTINE	SPECIAL	INITIAL
LOCATION	**PLANT**	
I.D. NO.	**BATTERY DATE**	
BATTERY TYPE	**INSPECTION DATE**	
CELL TEMP. ° F **TOP**	**MIDDLE**	**BOTTOM**
FLOAT VOLTS	EQUALIZE VOLTS	LOAD AMPS

CELL DATA READINGS

Cell No.	Float	Equalize	Spec Grav		Cell No.	Float	Equalize	Spec Grav
1.	2.	2.	1.2		31.	2.	2.	1.2
2.	2.	2.	1.2		32.	2.	2.	1.2
3.	2.	2.	1.2		33.	2.	2.	1.2
4.	2.	2.	1.2		34.	2.	2.	1.2
5.	2.	2.	1.2		35.	2.	2.	1.2
6.	2.	2.	1.2		36.	2.	2.	1.2
7.	2.	2.	1.2		37.	2.	2.	1.2
8.	2.	2.	1.2		38.	2.	2.	1.2
9.	2.	2.	1.2		39.	2.	2.	1.2
10.	2.	2.	1.2		40.	2.	2.	1.2
11.	2.	2.	1.2		41.	2.	2.	1.2
12.	2.	2.	1.2		42.	2.	2.	1.2
13.	2.	2.	1.2		43.	2.	2.	1.2
14.	2.	2.	1.2		44.	2.	2.	1.2
15.	2.	2.	1.2		45.	2.	2.	1.2
16.	2.	2.	1.2		46.	2.	2.	1.2
17.	2.	2.	1.2		47.	2.	2.	1.2
18.	2.	2.	1.2		48.	2.	2.	1.2
19.	2.	2.	1.2		49.	2.	2.	1.2
20.	2.	2.	1.2		50.	2.	2.	1.2
21.	2.	2.	1.2		51.	2.	2.	1.2
22.	2.	2.	1.2		52.	2.	2.	1.2
23.	2.	2.	1.2		53.	2.	2.	1.2
24.	2.	2.	1.2		54.	2.	2.	1.2
25.	2.	2.	1.2		55.	2.	2.	1.2
26.	2.	2.	1.2		56.	2.	2.	1.2
27.	2.	2.	1.2		57.	2.	2.	1.2
28.	2.	2.	1.2		58.	2.	2.	1.2
29.	2.	2.	1.2		59.	2.	2.	1.2
30.	2.	2.	1.2		60.	2.	2.	1.2

Comments:

STATIONARY BATTERY REPORT
INTER-CELL CONNECTION TEST

LOCATION	**PLANT**
I.D. NO.	**BATTERY DATE**
BATTERY TYPE	**INSPECTION DATE**
POS. TERM. TO POS. BUS	**NEG. TERM. TO NEG. BUS**

CELL NO.	MICRO-OHMS	CELL NO.	MICRO-OHMS	CELL NO.	MICRO-OHMS
1 to 2	/	21 to 22	/	41 to 42	/
2 to 3	/	22 to 23	/	42 to 43	/
3 to 4	/	23 to 24	/	43 to 44	/
4 to 5	/	24 to 25	/	44 to 45	/
5 to 6	/	25 to 26	/	45 to 46	/
6 to 7	/	26 to 27	/	46 to 47	/
7 to 8	/	27 to 28	/	47 to 48	/
8 to 9	/	28 to 29	/	48 to 49	/
9 to 10	/	29 to 30	/	49 to 50	/
10 to 11	/	30 to 31	/	50 to 51	/
11 to 12	/	31 to 32	/	51 to 52	/
12 to 13	/	32 to 33	/	52 to 53	/
13 to 14	/	33 to 34	/	53 to 54	/
14 to 15	/	34 to 35	/	54 to 55	/
15 to 16	/	35 to 36	/	55 to 56	/
16 to 17	/	36 to 37	/	56 to 57	/
17 to 18	/	37 to 38	/	57 to 55	/
18 to 19	/	38 to 39	/	58 to 59	/
19 to 20	/	39 to 40	/	59 to 60	/
20 to 21	/	40 to 41	/		

Identify inter-cell cable connections between racks or shelves (tiers) with an asterisk *.

Comments:_____

TABLE NO. I
VOLTAGE FOR LEAD ACID BATTERIES WITH 1.215 SPECIFIC GRAVITY
FLOAT VOLTAGE

NO. OF CELLS	LEAD ANTIMONY	LEAD CALCIUM, LEAD SELENIUM	SEALED VRLA ABSORBED GLASS MATT
	(Normal Cell Volts) 2.17 to 2.19	(Normal Cell Volts 2.25) See note 1	(Normal Cell Volts 2.25) See note 2
11	--	24.8	25.0
12	26.0	27.0	27.0
23	--	51.8	52.0
24	52.0	54.0	54.0
58	--	130.5	131.0
60	130.2	135.0	135.0
120	260.5	270.0	--

EQUALIZE VOLTAGE (2.33 VOLTS PER CELL)
INCLUDES VRLA TYPES

NO. OF CELLS	LEAD ANTIMONY	LEAD CALCIUM, LEAD SELENIUM
11	25.6	25.6
12	28.0	28.0
23	54.0	54.0
24	56.0	56.0
58	135.0	135.0
60	140.0	140.0
120	280.0	280.0

NOTE: (1) Lead Selenium batteries such as ALCAD, and VARTA are 1.240 specific gravity, but maybe Float charged at 2.23 to 2.25 VDC.

NOTE: (2) Sealed VRLA (Valve Regulated Lead Acid) types may be floated between 2.21 to 2.27 VDC depending on cell temperature and manufacture specifications. Refer to appropriate Instruction manuals.

TABLE II
INTER-CELL CONNECTOR RETORQUE VALUES

ALCAD	TORQUE VALUES (INCH POUNDS)
SD, SDH (ALL)	80

C&D CO. CELLS	TORQUE VALUES (INCH POUNDS)
DCU Multi cells	60
D Type Single cells	100
JC (All)	100
KC & KCR - 5 thru 13	100
KC & KCR - 15 thru 21	125
LCT (All)	100
LCR - 19 thru 33	125
LIBERTY 2000 VRLA CELLS (All)	125
LIBERTY 1000 VRLA cells	
25 thru 50 A.H. size	40
55 thru 300 A.H. size	100
XTJ and XTK	125
XTL (All)	125

YUASA EXIDE CO. CELLS	TORQUE VALUES (INCH POUNDS)
CA, CC, CX (All)	65
DMP (All)	60
EMP, EU, EX-5 thru 15	110
EA, EC	65
EHGS, FTA,FTC (All)	110
ES - 5 thru 13	65

G.N.B. CO. CELLS	TORQUE VALUES (INCH POUNDS)
D Type (All)	100
M and N Types 1/8” bars	100
M and N Types 1/4” bars	150
ABSOLYTE II (Sealed Cells)	100
PDQ, N and H Types	150

JOHNSON CONTROL (GLOBE) CELLS	TORQUE VALUES (INCH POUNDS)
G Series (Lead Nuts)	85
G Series (Stainless)	60
UPX (8 Volt Cells)	85
UPX (2 Volt Cells)	125

VARTA CELLS	TORQUE VALUES (INCH POUNDS)
Vb 428 thru Vb 611	66
Vb 2305 & Vb 2420	220
OPZS	220

NOTE: Torque Values shown are to be used for re-torque of connections after initial installation. Any question or battery types not listed consult with Electric Maintenance or Manufactures Instruction Manuals.

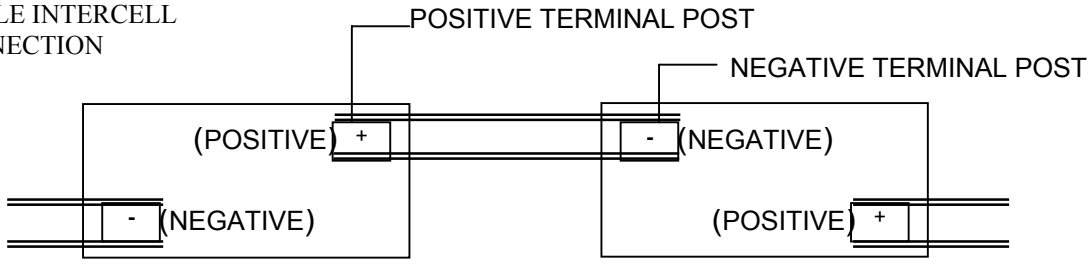
CAUTION: Be aware of connection hardware (bolts/nuts) which may strip or turn too many times when being torqued. Such cases may indicate faulty hardware or torque values, or terminal post problems.

Generally, all battery connections should be torqued to the values specified annually. Exceptions to this recommendation, would be batteries which are heavily loaded or received excessive discharge events, such as UPS batteries or faulted DC systems.

If such event discharges occur, then it is recommended this procedure be re-implemented, and the battery system be re-examined for any changes.

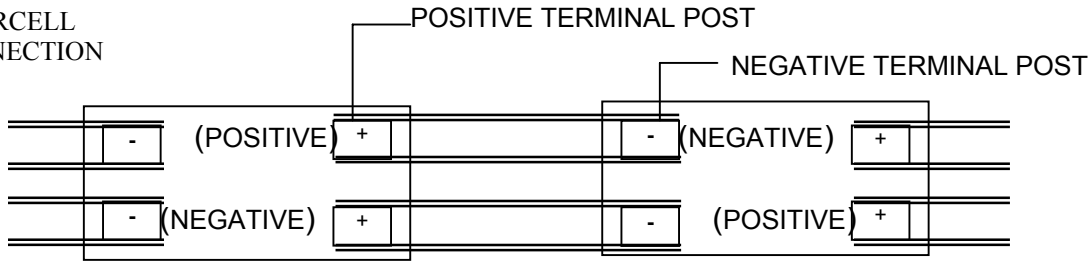
TYPICAL SINGLE OR PARALLEL POST INTERCELL CONNECTIONS

FIG. 1
SINGLE INTERCELL CONNECTION



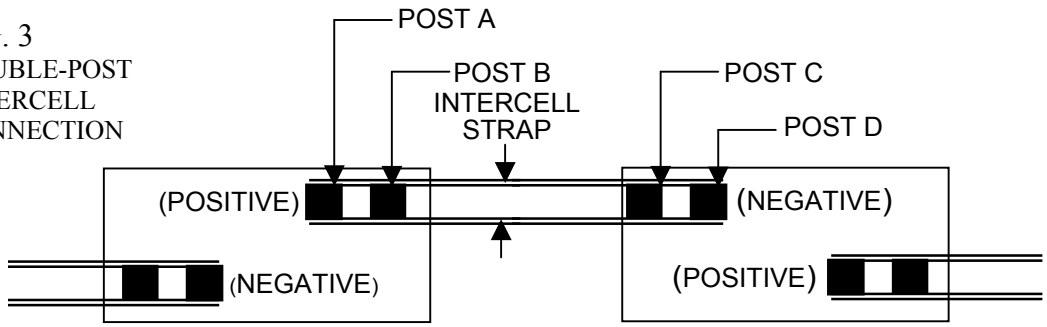
MEASURE INTERCELL CONNECTION RESISTANCE BETWEEN POSITIVE TERMINAL POST TO THE NEGATIVE TERMINAL POST.

FIG. 2
PARALLEL-POST INTERCELL CONNECTION



MEASURE INTERCELL CONNECTION RESISTANCES BETWEEN BOTH PARALLEL-POST CONNECTIONS AND COMPARE VALUES.

FIG. 3
DOUBLE-POST INTERCELL CONNECTION



MEASURE INTERCELL CONNECTION RESISTANCES BETWEEN POST "A" TO POST "C", AND POST "B" TO POST "D" AND COMPARE VALUES.

Oil Circuit Breaker Detailed Inspection

1. Purpose

The purpose of this procedure is to provide instructions for the testing and maintenance of the Power Circuit Breakers for Mechanical and Electrical Integrity.

2. Definitions

2.1. **Testing and repairs** includes the following:

2.1.1. Cleaning devices.

2.1.2. Tightening and re-gasketing on manhole cover, bushing, etc.

2.1.3. Replacement of failed parts with identical parts is allowable.

2.1.4. Measuring and recording “as found” and “as left” conditions.

Note: Normal repairs do not include modifications of relays or control schemes.

2.2. **"As Found"** measurements are measurements made before any cleaning, adjusting, or repairing is done on a device.

2.3. **"As Left"** measurements are measurements made after cleaning, adjusting, and repairing have been completed on a device.

2.4. **Bypass**

Any device which blocks a component out of service or which prevents it from performing its intended function. Example: An electrical jumper or lifted wires.

3. Equipment Needed

3.1. Properly stocked maintenance vehicle.

4. References

4.1. Electrical

4.1.1. Circuit Breaker Instruction Book.

4.1.2. Single-line diagrams.

4.1.3. Three-line diagrams.

4.2. Standards

4.2.1. ANSI-C37.06-1997, AC High-Voltage Circuit Breakers.

5. Procedure

5.1. Precautions

5.1.1. Maintenance provider personnel shall take necessary precautions to prevent accidental contact with high voltage equipment as per the Xcel Energy Safety Manual.

5.1.2. Flammable solvents and cleaning fluids shall be kept in approved containers. The containers shall be labeled ***FLAMMABLE*** and shall have the type of material indicated on them per **(MSDS).**

5.1.3. All material must be on the approved list of Xcel Energy Hazardous Material Procurement Program.

5.1.4. Maintenance provider personnel shall take necessary precautions for the following:

5.1.4.1. Shall take necessary precautions to properly ground equipment to discharge capacitive charges induced through service or testing.

5.1.4.2. Shall take necessary precautions never to touch any leads, terminal, bushings, etc., with test equipment energized.

5.1.4.3. Post **"Danger High Voltage"** signs as necessary and barricade appropriate areas on top of the circuit breaker and the ground for personnel protection.

5.1.4.4. Covers or fittings shall not be opened unless zero gauge pressure exists inside the unit. Always relieve internal pressures slowly through valves.

5.1.5. Insulating oil must always be handled as flammable liquid. Closed circuit breaker tanks may, under some conditions, accumulate explosive gases, and oil handling procedures may generate static electricity. Proper grounding is imperative.

5.1.6. Refer to the manufacture's instruction manual for test requirements and as certain manufactures may recommend additional tests which may not be included in the procedure.

5.1.7. Write N/A on the **Oil Circuit Breaker Detailed Inspection List** for the tests not applicable to the circuit breaker being tested.

5.2. Test

NOTE: Use pen in completing all forms. Results of the following steps shall be documented on Oil Circuit Breaker Detailed Inspection List Pages. Each step of these instructions shall be initialed prior to starting the next step.

5.2.1. If required, Verify Supervisor has authorized work to start. _____

5.2.2. Tailgate (See tailgate check-off list). _____

5.2.3. Inspect the circuit breaker and accessories for external physical damage to paint finish, tanks, bushings and any indications of leaks. Record "as found" and "as left" condition in comment section on **Oil Circuit Breaker Detailed Inspection List**. _____

5.2.4. Check oil levels on Main Tank and Bushings. Record "as found" and "as left" oil levels in comment section on **Oil Circuit Breaker Detailed Inspection List.** _____

5.2.5. Inspect and ensure that the tank and frame are permanently and adequately grounded. Record "as found" and "as left" condition in comment section on **Oil Circuit Breaker Detailed Inspection List.** _____

5.2.6. Inspect compressor for oil leaks, vibration, check motor rotation and that connections are in good working order. Record "as found" and "as left" condition in comment section on **Oil Circuit Breaker Detailed Inspection List.** _____

5.2.7. Inspect Control Cabinet for moisture and condition of door gaskets. Check relay coils for excessive noise, discoloring, burning odor and charred wiring, check connections for tightness and check heaters. Record "as found" and "as left" condition in comment section on **Oil Circuit Breaker Detailed Inspection List.** _____

5.3. Close-out

5.3.1. Complete the **Oil Circuit Breaker Detailed Inspection List.** Record all required information including "As Found" conditions that may have prevented proper operation of the circuit breaker. _____

5.3.2. Ensure **all data forms** are completed and attached. _____

5.3.3. Reviewed by System Engineer. _____

OIL CIRCUIT BREAKER DETAILED INSPECTION LIST

(attach as many sheets as necessary)

Substation _____
Breaker # _____

1) **Inform – Systems Operation, Trouble Foreman or Local Dispatch, that you are in the substation performing maintenance.**

2) Visually inspect general condition of equipment:

	Condition	Needs Attn.	Remarks
a) Bushings (oil levels, broken etc.)			
b) Main tank (oil levels)			
c) Oil Leaks			
d) Control Cabinet			
e) Grounding connections			
f) Is schematic in the control cabinet?			
3) Check fuses, heaters and thermostats.			
4) Sample oil and test:			
a) Oil clarity			
b) Dielectric (should be >25kV)			
5) Compressor (as applicable)			
a) Note hours of run-time			
b) Check belt, oil level, check valve, and pulleys			
c) Oil leaks			
6) Mechanism			
a) Visually inspect general condition.			
b) Clean mechanism cabinet.			
c) Check fuses, heaters & thermostats.			
d) Pneumatic: Weather permitting: drain moisture from air tanks and check pressure switches.			
e) Hydraulic: Lower pressure, check pressure switches, and pre-charge.			
7) Change oil in air compressor (Tag compressor with a tag showing oil type and date of change.)			

8) Check the safety relief valve for proper operation and tag showing date tested. _____ _____ _____

Comments:

_____
_____
_____
_____
_____
_____
_____

Complete inspection sheets and return to office.

Voltage Regulator Detailed Inspection

1. Purpose

The purpose of this procedure is to provide instructions for the testing and maintenance of the Voltage Regulators for Mechanical and Electrical Integrity.

2. Definitions

2.1. **Testing and repairs** includes the following:

2.1.1. Cleaning devices.

2.1.2. Tightening and re-gasketing on manhole cover, bushing, etc.

2.1.3. Replacement of failed parts with identical parts is allowable.

2.1.4. Measuring and recording “as found” and “as left” conditions.

Note: Normal repairs do not include modifications of relays or control schemes.

2.2. **"As Found"** measurements are measurements made before any cleaning, adjusting, or repairing is done on a device.

2.3. **"As Left"** measurements are measurements made after cleaning, adjusting, and repairing have been completed on a device.

2.4. **Bypass**

Any device which blocks a component out of service or which prevents it from performing its intended function. Example: An electrical jumper or lifted wires.

3. Equipment Needed

3.1. Properly stocked maintenance vehicle.

4. References

4.1. Electrical

4.1.1. Voltage Regulator Instruction Book.

4.2. Standards

4.2.1. ANSI-C57.12.00-1993, General requirements for Liquid-Immersed Distribution, Power and Regulating Transformers.

5. Procedure

5.1. Precautions

5.1.1. Maintenance provider personnel shall take necessary precautions to prevent accidental contact with high voltage equipment as per the Xcel Energy Safety Manual.

5.1.2. Flammable solvents and cleaning fluids shall be kept in approved containers. The containers shall be labeled ***FLAMMABLE*** and shall have the type of material indicated on them per **(MSDS).**

5.1.3. All material must be on the approved list of Xcel Energy Hazardous Material Procurement Program.

5.1.4. Maintenance provider personnel shall take necessary precautions for the following:

5.1.4.1. Shall take necessary precautions to properly ground equipment to discharge capacitive charges induced through service or testing.

5.1.4.2. Shall take necessary precautions never to touch any leads, terminal, bushings, etc., with test equipment energized.

5.1.4.3. Post **"Danger High Voltage"** signs as necessary and barricade appropriate areas on top of the voltage regulator and the ground for personnel protection.

5.1.4.4. Covers or fittings shall not be opened unless zero gauge pressure exists inside the unit. Always relieve internal pressures slowly through valves.

5.1.5. Insulating oil must always be handled as flammable liquid. Voltage regulator tanks may, under some conditions, accumulate explosive gases, and oil handling procedures may generate static electricity. Proper grounding is imperative.

5.1.6. Refer to the manufacture's instruction manual for test requirements and as certain manufactures may recommend additional tests which may not be included in the procedure.

5.1.7. Write N/A on the **Voltage Regulator Detailed Inspection List** for the tests not applicable to the voltage regulator being tested.

5.2. Test

NOTE: Use pen in completing all forms. Results of the following steps shall be documented on Voltage Regulator Detailed Inspection List Pages. Each step of these instructions shall be initialed prior to starting the next step.

5.2.1. If required, Verify Supervisor has authorized work to start. _____

5.2.2. Tailgate (See tailgate check-off list). _____

5.2.3. Inspect the voltage regulator and accessories for external physical damage to paint finish, tanks, radiators, bushings and any indications of leaks. Record "as found" and "as left" condition in comment section on **Voltage Regulator Detailed Inspection List**. _____

5.2.4. Check oil levels on Main Tank and Bushings. Record "as found" and "as left" oil levels in comment section on **Voltage Regulator Detailed Inspection List.** _____

5.2.5. Inspect and ensure that the tank and frame are permanently and adequately grounded. Record "as found" and "as left" condition in comment section on **Voltage Regulator Detailed Inspection List.** _____

5.2.6. Inspect fans for vibration and condition of blade. Ensure that fans motor are lubricated and that connections are in good working order. Record "as found" and "as left" condition in comment section on **Transformer and LTC Detailed Inspection List.** _____

5.2.7. Inspect Control Cabinet for moisture and condition of door gaskets. Check relay coils for excessive noise, discoloring, burning odor and charred wiring, check connections for tightness and check heaters. Record "as found" and "as left" condition in comment section on **Voltage Regulator Detailed Inspection List.** _____

5.2.8. If possible, run the tap changer up and down several taps and listen for unusual sounds, growling or grinding. _____

5.3. Close-out

5.3.1. Complete the **Voltage Regulator Detailed Inspection List.** Record all required information including "As Found" conditions that may have prevented proper operation of the voltage regulator. _____

5.3.2. Ensure **all data forms** are completed and attached. _____

5.3.3. Reviewed by System Engineer. _____

VOLTAGE REGULATOR DETAILED INSPECTION LIST

(attach as many sheets as necessary)

Substation _____
Regulator # _____

1) **Inform – Systems Operation, Trouble Foreman or Local Dispatch, that you are in the substation performing maintenance.**

2) Visually inspect general condition of equipment:

	Condition	Needs Attn.	Remarks
a) Bushings	_____	_____	_____
b) Oil Levels	_____	_____	_____
c) Oil Leaks	_____	_____	_____
d) Control Cabinet	_____	_____	_____
e) Grounding connections	_____	_____	_____
3) Check fuses, heaters and thermostats.	_____	_____	_____
4) Sample oil and test:			
a) Oil clarity	_____	_____	_____
b) Dielectric (should be >25kV)	_____	_____	_____
5) Tap Changer:			
a) Note number of operations	_____	_____	_____
b) Note operating range:	from _____ to _____	_____	_____
c) Currently on tap:	_____	_____	_____
d) Has the tap changer operated through neutral?	_____	_____	_____
e) Is the counter working?	_____	_____	_____
f) Oil Level (high, low, OK)	_____	_____	_____
g) Automatic operation	_____	_____	_____

Comments:

_____

_____

_____

_____

_____

Complete inspection sheets and return to office.

VOLTAGE REGULATOR DETAILED INSPECTION

LTC Inspection

1. Purpose

The purpose of this procedure is to provide instructions for the testing and maintenance of Load Tap Changers (LTC's.)

2. Definitions

2.1. Load Tap Changer (LTC) and On-Load Tap Changer (OLTC) and synonymous terms.

2.2. **Normal Repairs** include the following:

2.2.1. Cleaning devices.

2.2.2. Tightening fasteners such as screws and nuts.

2.2.3. Replacement of failed parts with identical parts is allowable.

NOTE: Normal repairs do not include modifications of relays or control schemes.

2.3. **"As Found"** measurements are measurements made before any cleaning, adjusting, or repairing is done on a device.

2.4. **"As Left"** measurements are measurements made after cleaning, adjusting, and repairing have been completed on a device.

2.5. **Maintenance Provider Technician**

That individual, trained and qualified in accordance with appropriate EM Testing Instructions and procedures, who has been designated by the EM Supervisor as having the responsibility for the correct performance of the work required by this procedure.

3. Equipment Needed

The following items are commonly required for this work. Each job may have specific requirements in addition to this general check list.

3.1. **"Danger High Voltage"** signs and barricades
3.2. Portable grounds (stored in substation control house)
3.3. Oil storage tank(s)
3.4. Maintenance Truck
3.5. JLG and/or scaffolding
3.6. Portable generator
3.7. Hypotronics Oil Dielectric test set with D-1816 or D-877 test cup
3.8. Programma Hi-Pot for vacuum LTC's

3.9. For suspect LTC switches, spare parts (e.g. contacts, reversing switch) should be on hand before beginning the inspection.

LTC switches currently on the suspect list due to high frequency of problems include:

- Westinghouse UTT and UTT-A
- McGraw Edison 550C
- General Electric LRT-72 and LRT-200

4. References

4.1. Transformer schematic (should be in control cabinet)
4.2. Manufacturers Instruction Manual.

5. Procedure

5.1. Precautions

5.1.1. Verify Operator has isolated the transformer and has authorized work to start.

5.1.2. Maintenance provider personnel shall take necessary precautions to prevent accidental contact with high voltage equipment as per the Xcel Energy Safety Manual.

5.1.3. Flammable solvents and cleaning fluids shall be kept in approved containers. The containers shall be labeled ***FLAMMABLE*** and shall have the type of material indicated on them per **(MSDS.)**

5.1.4. All material must be on the approved list of Xcel Energy Hazardous Material Procurement Program.

5.1.5. Maintenance provider personnel shall take necessary precautions for the following:

1. Shall take necessary precautions to properly ground equipment to discharge capacitive charges induced through service or testing.
2. Shall take necessary precautions never to touch any leads, terminals, bushings, etc., with test equipment energized. A transformer with a high turn to turn ratio transforms very small input voltages into dangerously high output voltages.
3. Post **"Danger High Voltage"** signs as necessary and barricade appropriate areas on top of the transformer and the ground for personnel protection.

5.1.6. The dielectric strength of oil is affected by the most minute traces of certain impurities, particularly water. It is important that the greatest care be taken in obtaining the samples and in handling them to avoid contamination.

5.1.7. Transformer oil must always be handled as flammable liquid. Closed transformer and load tap changer tanks may, under some conditions, accumulate explosive gases, and oil handling procedures may generate static electricity. Proper grounding is imperative.

5.1.8. Refer to the manufacture's instruction manual for test requirements, manufactures may recommend additional tests which may not be included in the procedure.

5.1.9. Write N/A on the transformer Test Report for the tests not applicable to the transformer being tested.

5.2. Instructions

NOTE: Use pen in completing all forms. Results of the following steps shall be documented on Maintenance and Test Report Pages or on this form where indicated. Each step of these instructions shall be initialed prior to starting the next step.

5.2.1. Tailgate (See Tailgate Check-Off List). _____

5.2.2. Collect a DGA oil sample from the main tank (this can and should be done the day before the inspection so results are available.) _____

5.2.3. Check isolation, post necessary "Danger High Voltage" signs, and ensure that the top of transformer is barricade appropriately. On **existing transformers**, test for dead and place personal grounds on transformer and associated equipment. _____

5.2.4. Open all control switches and fuses. _____

5.2.5. Record the following as-found information: _____
1. Running tap: _____
2. LTC Position drag hands: HI:_____ LO:_____

5.2.6. Remove vent plug or open valve from top of transformer LTC compartment and drain oil. (This includes filtering.) _____

Note: It is not necessary to circulate the oil at this time.

5.2.7. Open and ventilate compartment. _____

5.2.8. Clean carbon from LTC compartment and check bottom of compartment for broken or missing parts. _____

5.2.9. Visually inspect for abnormal conditions such as badly burnt contacts, damaged or loose parts, tracking on boards, leaks from main tank, cracked or leaking board or bushing seals, etc. _____

1. If any contacts appear to be burnt open, notify engineering immediately as this may indicate additional main transformer problems. Do not correct this condition until reviewed by engineering. _____
2. **Document all as-found conditions on the maintenance report.** _____

5.2.10. Make any necessary repairs as per Manufactures instruction book. _____

1. Immediately notify the supervisor or engineering if any component needs to be replaced or if unusual conditions are discovered. Take photos to document conditions. _____
2. List all replaced or repaired parts on the maintenance report. Be specific about as-found condition and location (e.g. which tap, moving or stationary.) **Return all removed parts to engineering for further evaluation.** _____

5.2.11. Operate LTC manually and check contact alignment on each poistion, bridging, spring compression, and mechanical stops. If equipment with vacuum bottles, high pot as per manufactures I.B. _____

5.2.12. Electrically operate when possible. _____

5.2.13. Check limit switches. _____

5.2.14. Check reversing switches. _____

5.2.15. Verify all tools, rags, equipment have been removed from compartment. _____

5.2.16. Check and reseal door gasket, close door. _____

LTC INSPECTION

5.2.17. Check oil before refilling the LTC and process if necessary _____

- Use the ANSI D-877 dielectric test for new oil or in free-breathing LTC's.
- Use the ANSI D-1816 dielectric test for sealed units.

5.2.18. Filter oil into LTC compartment. (Check Manufactures I.B. to see if LTC needs to have the oil OPU processed.) _____

5.2.19. Reinstall vent plug. _____

5.2.20. Test oil. _____

On breathing type LTC's (common) no additional testing is required.

For non-breathing LTC's (e.g. vacuum) collect oil samples for:

1. Karl Fisher
2. Insulating Oil
3. Dissolved Gas Analysis (DGA)

5.2.21. Inspect operating mechanism: _____

5.2.22. Clean and lubricate as per manufactures I.B. _____

5.2.23. Check fuses, heaters and thermostats. _____

5.2.24. Close all control switches and fuses. _____

5.2.25. Electrically operate through all LTC tap positions and verify limit switches work properly. _____

5.3. Close-out

5.3.1. Remove grounds. _____

5.3.2. Complete the **Maintenance and Test Report.** Record all required information including "As Found" conditions that may have prevented proper operation of the transformer. _____

5.3.3. Insure **all data forms** are completed and attached. _____

5.3.4. Reviewed by Engineer. _____

MAINTENANCE AND TEST REPORT

DATE _____

All initials shall be identified below:

Initial	Name (Print or write legibly)	Title
_____	_____	_____
_____	_____	_____

STATION/UNIT_____
SERIAL #_____
NAMEPLATE DATA

MANUFACTURER_____ **MODEL/STYLE** _____

VOLTAGE_____ **AMPS** _____

GALLONS OF OIL (LTC) _____ **Is a filtration pump installed on this LTC? ____ (Y/N)**

DESCRIBE AS-FOUND CONDITIONS:
OIL CONDITION _____
Were metal particles found in the oil? _____ (Y/N)
Describe or identify possible source: _____

_____

CONTACTS:
Describe wear. Were some contacts more worn than others? Which ones? _____

_____

WORK DONE (EXPLAIN IN DETAIL)_____

_____

_____

_____

_____

_____

_____

_____

_____

LTC INSPECTION

Gas Circuit Breaker Detailed Inspection

1. Purpose

The purpose of this procedure is to provide instructions for the testing and maintenance of the Power Circuit Breakers for Mechanical and Electrical Integrity.

2. Definitions

2.1. **Testing and repairs** includes the following:

2.1.1. Cleaning devices.

2.1.2. Tightening and re-gasketing on manhole cover, bushing, etc.

2.1.3. Replacement of failed parts with identical parts is allowable.

2.1.4. Measuring and recording “as found” and “as left” conditions.

Note: Normal repairs do not include modifications of relays or control schemes.

2.2. **"As Found"** measurements are measurements made before any cleaning, adjusting, or repairing is done on a device.

2.3. **"As Left"** measurements are measurements made after cleaning, adjusting, and repairing have been completed on a device.

2.4. **Bypass**

Any device which blocks a component out of service or which prevents it from performing its intended function. Example: An electrical jumper or lifted wires.

3. Equipment Needed

3.1. Properly stocked maintenance vehicle.

4. References

4.1. Electrical

4.1.1. Circuit Breaker Instruction Book.

4.1.2. Single-line diagrams.

4.1.3. Three-line diagrams.

4.2. Standards

4.2.1. ANSI-C37.06-1997, AC High-Voltage Circuit Breakers.

5. Procedure

5.1. Precautions

5.1.1. Maintenance provider personnel shall take necessary precautions to prevent accidental contact with high voltage equipment as per the Xcel Energy Safety Manual.

5.1.2. Flammable solvents and cleaning fluids shall be kept in approved containers. The containers shall be labeled ***FLAMMABLE*** and shall have the type of material indicated on them per **(MSDS).**

5.1.3. All material must be on the approved list of Xcel Energy Hazardous Material Procurement Program.

5.1.4. Maintenance provider personnel shall take necessary precautions for the following:

5.1.4.1. Shall take necessary precautions to properly ground equipment to discharge capacitive charges induced through service or testing.

5.1.4.2. Shall take necessary precautions never to touch any leads, terminal, bushings, etc., with test equipment energized.

5.1.4.3. Post **"Danger High Voltage"** signs as necessary and barricade appropriate areas on top of the circuit breaker and the ground for personnel protection.

5.1.4.4. Covers or fittings shall not be opened unless zero gauge pressure exists inside the unit. Always relieve internal pressures slowly through valves.

5.1.5. Closed circuit breaker tanks may, under some conditions, accumulate explosive gases, and procedures may generate static electricity. Proper grounding is imperative.

5.1.6. Refer to the manufacture's instruction manual for test requirements and as certain manufactures may recommend additional tests which may not be included in the procedure.

5.1.7. Write N/A on the **Gas Circuit Breaker Detailed Inspection List** for the tests not applicable to the circuit breaker being tested.

5.2. Test

NOTE: Use pen in completing all forms. Results of the following steps shall be documented on Gas Circuit Breaker Detailed Inspection List Pages. Each step of these instructions shall be initialed prior to starting the next step.

5.2.1. If required, Verify Supervisor has authorized work to start. _____

5.2.2. Tailgate (See tailgate check-off list). _____

5.2.3. Inspect the circuit breaker and accessories for external physical damage to paint finish, tanks, bushings and any indications of leaks. Record "as found" and "as left" condition in comment section on **Gas Circuit Breaker Detailed Inspection List**. _____

5.2.4. Check gas pressures on Tank and Bushings. Record "as found" and "as left" oil levels in comment section on **Gas Circuit Breaker Detailed Inspection List.** _____

5.2.5. Inspect and ensure that the tank and frame are permanently and adequately grounded. Record "as found" and "as left" condition in comment section on **Gas Circuit Breaker Detailed Inspection List.** _____

5.2.6. Inspect compressor for oil leaks, vibration, check motor rotation and that connections are in good working order. Record "as found" and "as left" condition in comment section on **Gas Circuit Breaker Detailed Inspection List.** _____

5.2.7. Inspect Control Cabinet for moisture and condition of door gaskets. Check relay coils for excessive noise, discoloring, burning odor and charred wiring, check connections for tightness and check heaters. Record "as found" and "as left" condition in comment section on **Gas Circuit Breaker Detailed Inspection List.** _____

5.3. Close-out

5.3.1. Complete the **Gas Circuit Breaker Detailed Inspection List.** Record all required information including "As Found" conditions that may have prevented proper operation of the circuit breaker. _____

5.3.2. Ensure **all data forms** are completed and attached. _____

5.3.3. Reviewed by System Engineer. _____

GAS CIRCUIT BREAKER DETAILED INSPECTION LIST

(attach as many sheets as necessary)

Substation _____
Breaker # _____

1) **Inform – Systems Operation, Trouble Foreman or Local Dispatch, that you are in the substation performing maintenance.**

2) Visually inspect general condition of equipment:

	Condition	Needs Attn.	Remarks
a) Bushings (oil levels, broken etc.)			
b) Main tank			
c) Gas pressure (s)			
d) Control Cabinet			
e) Grounding connections			
f) Is the BKR schematic in the control cabinet?			
g) Note any conditions requiring an outage to repair.			
3) Check fuses, heaters and thermostats.			
4) Compressor (as applicable)			
a) Note hours of run-time			
b) Check belt, oil level, check valve, and pulleys			
c) Oil leaks			
5) Mechanism			
a) Visually inspect general condition.			
b) Clean mechanism cabinet.			
c) Check fuses, heaters & thermostats.			
d) Pneumatic: Weather permitting: drain moisture from air tanks and check pressure switches.			
e) Hydraulic: Lower pressure, check pressure switches, and pre-charge.			
6) Change oil in air compressor (Tag compressor with a tag showing oil type and date of change.)			

Comments:

Complete inspection sheets and return to office.

GAS CIRCUIT BREAKER DETAILED INSPECTION

Substation Relay Inspections

Substation _____

1. Purpose

This procedure is for the routine relay inspection of Xcel Energy substations.

2. Definitions

2.1. **Inspection** includes the following:

2.1.1. Cleaning devices.
2.1.2. Testing as required.
2.1.3. Repairing or Correcting sub-standard conditions where possible.
2.1.4. Noting "as-left" conditions that require further attention.
2.1.5. Recording "as found" and "as left" conditions.

2.2. **As-Found"** measurements are measurements made before any cleaning, adjusting, or repairing is done on a device.

2.3. **"As-Left"** measurements are measurements made after cleaning, adjusting, and repairing have been completed on a device.

2.4. **Maintenance Provider Technician**

That individual, trained and qualified in accordance with appropriate testing instructions and procedures, who has been designated by the Supervisor as having the responsibility for the correct performance of the work required by this procedure.

3. Equipment Needed

3.1. A properly stocked Maintenance vehicle
3.2. Inspection Forms
3.3. Digital multimeter
3.4. Hold tags
3.5. Various fuses for replacement

4. References

4.1. None

5. Procedure

5.1. Precautions

5.1.1. Maintenance provider personnel shall take necessary precautions to prevent accidental contact with high voltage equipment as per the Xcel Energy Safety Manual.

5.1.2. Contact System Operator or Regional Dispatcher prior to inspection and inform them that you are in the substation performing maintenance. _____

5.2. Instructions

NOTE: Use pen in completing all forms. Results of the following steps shall be documented on Inspection Report Pages. Each step of these instructions shall be initialed when complete.

Check, Correct and/or document any irregularities found.

5.2.1. Inspect potential device secondary fuses _____
- Test for continuity
- Check physical condition
- Replace when necessary

5.2.2. Inspect all panels for correct switch positions _____
- Check 43, 97, trip, current, potential, and test switches
- If a switch is to be left in a state other than normal, ensure it is properly tagged

5.2.3. Inspect station aux transfer switch _____
- I nspect internal relays and contacts
- C heck normal and emergency source voltage
- T est transfer and return to normal operation

5.2.4. Inspect station annuciators _____
- Test main and remote annuciators for supply power and test lights

5.2.5. Test battery systems for grounds _____

5.2.6. Test load side of all DC fuses for proper voltage _____

5.2.7. Test load side of all AC fuses for proper voltage _____

5.2.8. Inspect for proper indication lights _____
- Check bulbs
- Inventory bulb and lens styles for LED upgrade (in station and in outdoor equipment if necessary.)

Substation Relay Inspections

5.2.9. Check all panel and terminal cabinet terminals for tightness (where possible and if reasonable) – this test should be performed by feeling the conductors for tightness at the termination. _____

5.2.10. Inspect gauges (visual) _____
- Look for expected reading
- Cracked or broken glass
- Moisture

5.2.11. Inspect panels, junction boxes, safety switches, wave traps, tuning devices for rodent nests, moisture, or overheating, etc. _____

5.2.12. Check station one-line diagram is the most current issues. _____

5.2.13. Check with EMS technician to ensure station metering indicates proper load flows and power-in equals power-out. _____

5.2.14. Check panel meters for balanced loading indication. _____

5.2.15. Check telephone loopback devices are passive devices or are supplied from station battery _____

5.2.16. Complete Telephone Cabinet Inspection checklist _____

5.2.17. Verify emergency phone number is displayed and that station location emergency directions are shown. _____

5.3. <u>Close-out</u>

5.3.1. Complete all **Inspection Forms.** Record all required information including work done and "As Found" conditions that may have prevented proper operation of the equipment. _____

5.3.2. Insure **all data forms** are completed and attached. _____

5.3.3. Reviewed by Engineer. _____

Completed by: _____ Date: _____

_____ Date: _____

Substation Relay Inspections

TELEPHONE CABINET INSPECTION SHEET

(attach as many sheets as necessary)

Substation _____

OK	NEEDS ATTN.		REMARKS
___	_____	Cabinet is clean & accessible.	_____
___	_____	Unprotected (Phone Co.) wiring is kept away from station ground	_____
___	_____	Gas tubes are **NOT** connected on the unprotected (Phone Co.) wiring. ***(Remove gas tubes if they exists on the Phone Co. wiring.)***	_____
___	_____	Separation is maintained between protected and unprotected wiring (If NO – please draw a sketch on back of form.)	_____
___	_____	Schematic of telephone cabinet is up-to-date (If **NO** – please RED & GREEN print and return to EM&P)	_____
___	_____	Telephone protection is **NOT** bypassed or missing	_____
___	_____	Number of Hi-Guards in cabinet _____	_____
		Number powered with DC-DC _____	_____
		Number powered with R-Zener _____	_____
___	_____	Number of Isolation transformers in cabinet ____	_____
___	_____	Number of Positron modules _____	_____
___	_____	Number of Lyte Lynx modules _____	_____
___	_____	Number of loopback modules _____	_____
___	_____	All Loopbacks are powered from a DC-DC converter (If **NO** – note power source, # of modules powered & circuits)	_____

Completed by: _____ Date: _____

Complete inspection sheets and return to office.

Substation Relay Inspections

Doble Protest Testing

1. Purpose

This procedure describes the general steps for running the Doble Protest automated testing equipment.

2. Definitions

2.1.
2.2.

3. Equipment Needed

3.1. Test Equipment

3.1.1. Doble Test Set - containing three (3) phase Voltage and one(1) high Current units at minimum.

3.2. Software

3.2.1. Doble Protest program. (e.g. Relay System Test Plan for the Solid State Distance Scheme)

4. References

4.1. Doble Protest Instruction book
4.2. Xcel Energy Control Standard Book

5. Procedure

5.1. Getting Started

SOFTWARE USAGE FOR RELAY TESTING: (The following is a sample for explanation purposes only and, hence, will not be identical to those that you may actually see.)

5.1.1. After turning **ON** the laptop, choose **PROTEST3** in the startup menu and press **ENTER.** _____

5.1.2. After the **C:** prompt, type: **"PT3"** and *press* **ENTER .** This will take you into the **ProTest** software. _____

5.1.3. Enter your name in the Username Field. Click on PROTEST. [see fig.1]. _____

5.1.4. Select the **Location Name** (i.e. substation), by using arrow keys: ↑ and ↓. (↓ key also allows you to enter a new field in

any level of this program.---if it does not, *press* **F3**, then ↓, and *enter* the new field.) [see fig. 2]. _____

5.1.5. *Press* **Fl.** This will take you into the **TERMINAL ID** level of the program [see fig.3]. Select the line name Primary or Secondary relaying. (Note: **Fl** will always take you forward one level into the program and **F10** will always take you backward one level out of the program). _____

5.1.6. *Press* **Fl** to go forward into the **RELAY ID** program level (see fig.4). *Highlight the* relay of interest and verify the information contained within. _____

5.1.7. *Press* **Fl** to move forward into the **RELAY TEST PLAN** program level [see fig.5]. This level will list a number of tests involved with the particular relay that you have chosen. Each test plan is defined by a **'macro'.** *Press* **F4** in order to acquire a "pop-up *window"* list offering on Help Topics [see fig.6]. Use the down arrow key [↓] to choose **MACRO** in the listing. Then *press* **ENTER** ↵ to give you a listing of all macros and their function* [see fig.7]. Use **Down Arrow Key** [↓] or **"Pg Dn Key"** to select a particular **"Macro"** (i.e.: SSIMUL). Press **"ENTER"** [↵]**.** _____

5.1.8. Pressing **Fl** while viewing **"AVAILABLE Protest III Macros"** (Fig. 7) will give a graphical representation of any selected test macro and the test values it will require. (see fig.8) _____

Note: *There is no graphics help for SSIMUL MACRO.*

5.1.9. After selecting the particular "**MACRO"** you will return to a screen as seen in Fig. 5. _____

SPECIAL INFORMATION:

Pressing **ALT & Fl** at the **"Test Plan Level"** (Fig. 5) will start the **Auto Testing Process** (see fig.9): this will execute the tests until a **NOTEBK** macro (see fig. 5 under **"MACRO"** column: **"NOTEBK"**) is encountered. Then, for example, if the **NOTEBK** note would direct the technician to change leads, he/she would do so; then hit **ENTER** ↵ to resume the auto-testing process (fig. 10).

Doble Protest Testing

5.2. **Running Test**

5.2.1. Pressing **Fl** at this point will take you into a specific test. _____

- For Non-SSIMUL MACRO test this specific test level will appear like fig. 11.

- For SSIMUL MACRO test the screen will appear like fig. 12

Fig. 11 (BSRHOI MACRO) shows:

1. 'Doble **Source** assignments',
2. their connection to the relay terminal # 's,
3. their values and ACTION conditions of the macro.

- These factors will affect and determine the individual relay element testing. **'Sense Connections'** are also shown. **MA** represents the **'Master'** source. [Note: The **'Action'** source - as defined by the **Test Plan** values - must be made the **'Master'** source].

- The **TAB** key may be used to take you into the left-half or the right-half of the computer screen.

5.2.2. *Pressing* Fl for Non-SSIMUL MACRO Test will **RUN** the **Macro Test** for you. [Test data of the **RUN** will be stored under the **F5** key. *Pressing* this key will allow you to *view* the test results. The **F6** key can be used to **PLOT** the test data]. _____

Fig. 12 (SSIMUL MACRO) shows the timer results from SSIMUL MACRO TEST.

5.2.3. *Pressing* **F1** for SSIMUL MACRO will take you to its Test Screen (Fig. 13). Fig. 13 shows various states of testing the relaying system. _____

5.2.4. *Pressing* **F1** again will run the MACRO Test for you. _____

Appendix

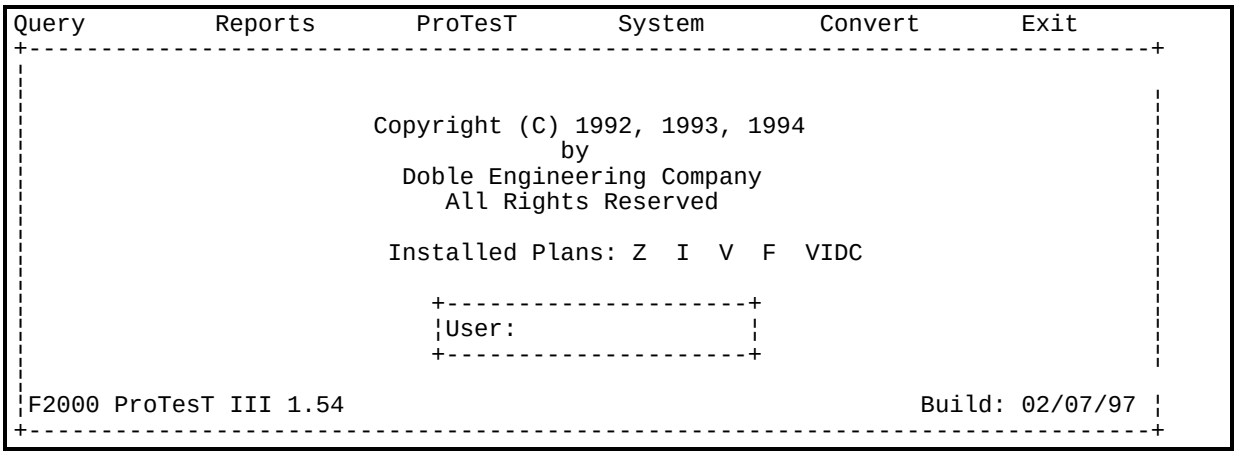


Fig. 1

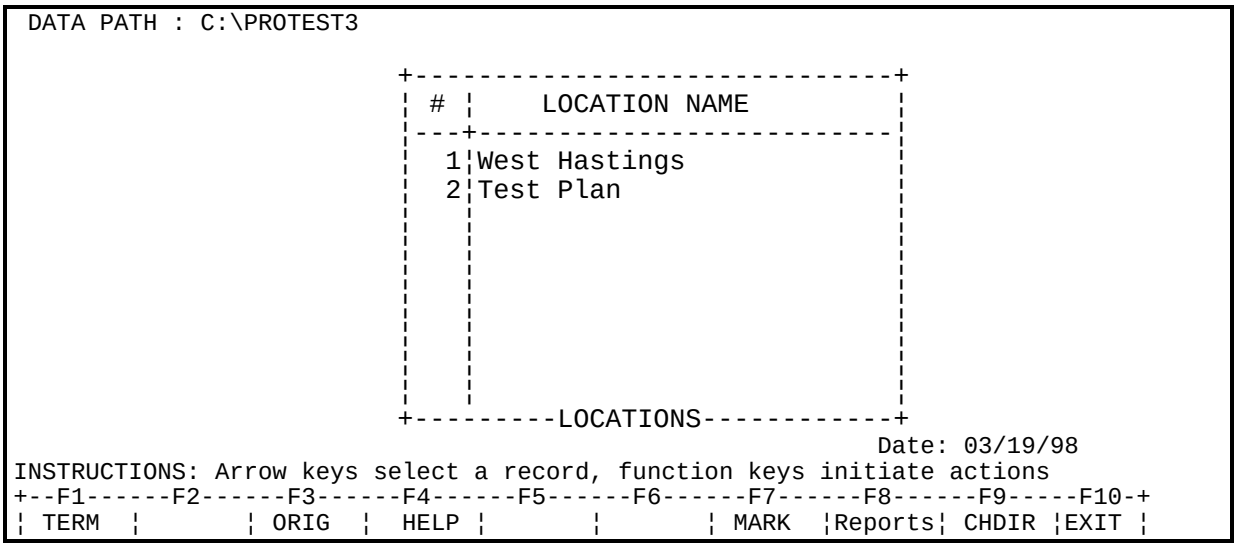


Fig. 2

Appendix
Doble Protest Testing

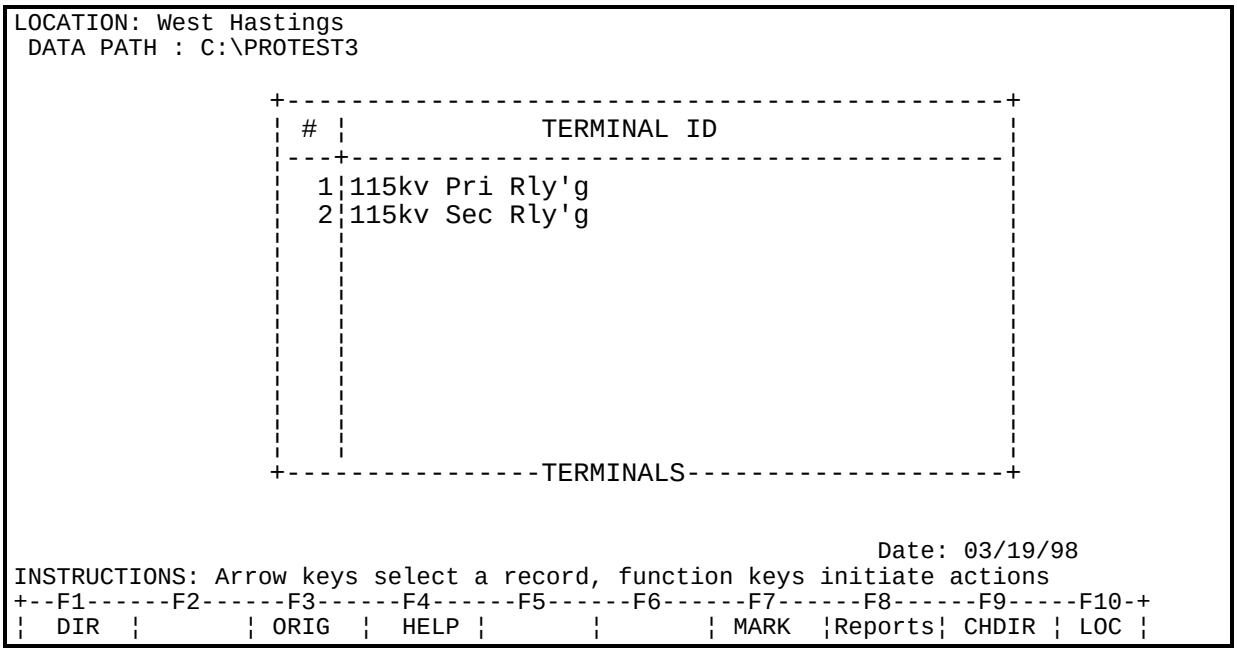


Fig. 3

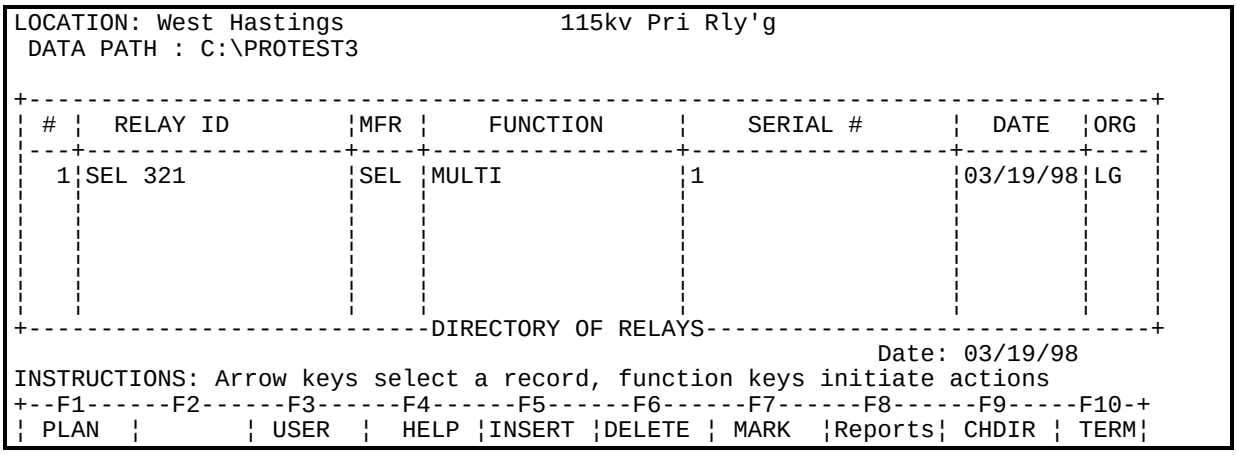


Fig.4

Appendix
Doble Protest Testing

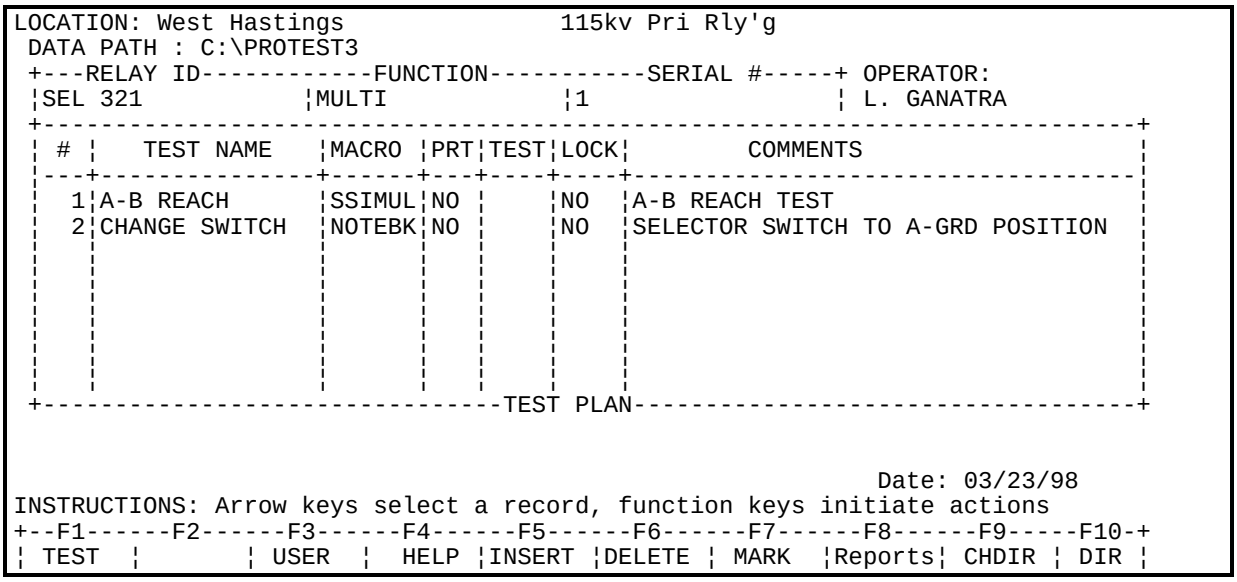


Fig. 5

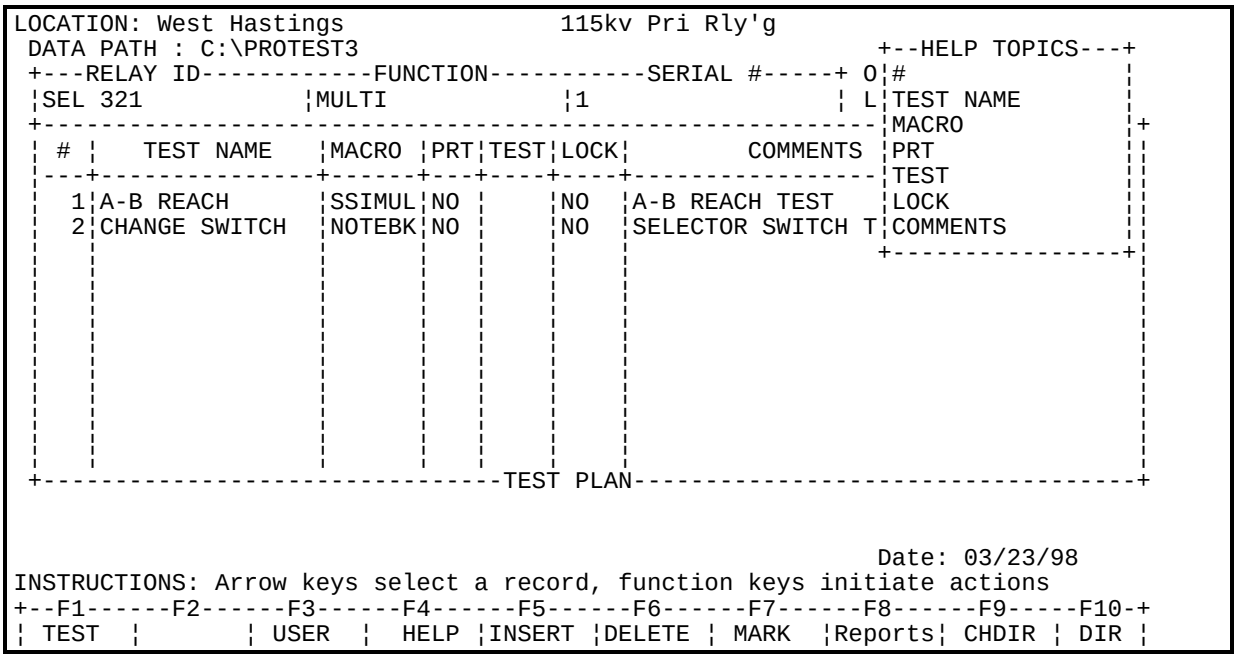


Fig. 6

Appendix
Doble Protest Testing

```
+----------------------- AVAILABLE ProTesT III MACROS -----------------------_
¦RCHBOI ¦ Reach Binary Search, Current.  Fast Search plus Ramp.                -
¦RCHBOV ¦ Reach Binary Search, Voltage.  Fast Search plus Ramp.                _
¦RCHLRI ¦ Reach Linear Ramp Current, from Offset to Pickup                    _
¦RCHLRV ¦ Reach Linear Ramp Voltage, from Offset to Pickup                    _
¦RCHPRI ¦ Reach Pulsed Ramp Current; Return to Offset between Pulses          _
¦RCHPRV ¦ Reach Pulsed Ramp Voltage; Return to Offset between Pulses          _
¦SSIMUL ¦ Run STATE SIMULATOR II from within ProTesT III                      _
¦TFRPLT ¦ Frequency vs. Time Characteristic; 12 Points with Pass/Fail         _
¦TIMEF  ¦ Operate Time for Frequency Shift                                    _
¦TIMEI  ¦ Operate Time for Step Change in Current                             _
¦TIMEPH ¦ Operate Time for Step Change in Phase                               _
¦TIMEV  ¦ Operate Time for Step Change in Voltage                             _
¦TOCPLT ¦ Current vs. Time Characteristic; 12 Points with Pass/Fail           _
¦TOVPLT ¦ Voltage vs. Time Characteristic; 12 Points with Pass/Fail           _
¦TPHPLT ¦ Phase Shift vs. Time Characteristic; 12 Points with Pass/Fail       _
¦ZPLBOI ¦ Z Plot Binary Search, Current; up to 100 Impedance Points           _
¦ZPLBOV ¦ Z Plot Binary Search, Voltage; up to 100 Impedance Points           _
¦ZPLLRI ¦ Z Plot Linear Ramp, Current; up to 100 Impedance Points             _
¦ZPLLRV ¦ Z Plot Linear Ramp, Voltage; up to 100 Impedance Points             □
¦ZPLPRI ¦ Z Plot Pulsed Ramp, Current; up to 100 Impedance Points             _
¦ZPLPRV ¦ Z Plot Pulsed Ramp, Voltage; up to 100 Impedance Points             _
¦ZPXBOI ¦ Z Plot Binary Search, Current; 12 Points with Pass/Fail             _
¦ZPXBOV ¦ Z Plot Binary Search, Voltage; 12 Points with Pass/Fail
+------ USE ENTER OR MOUSE CLICK TO SELECT, Esc TO RETURN , F1 to GRAPH -------_
```

Fig. 7

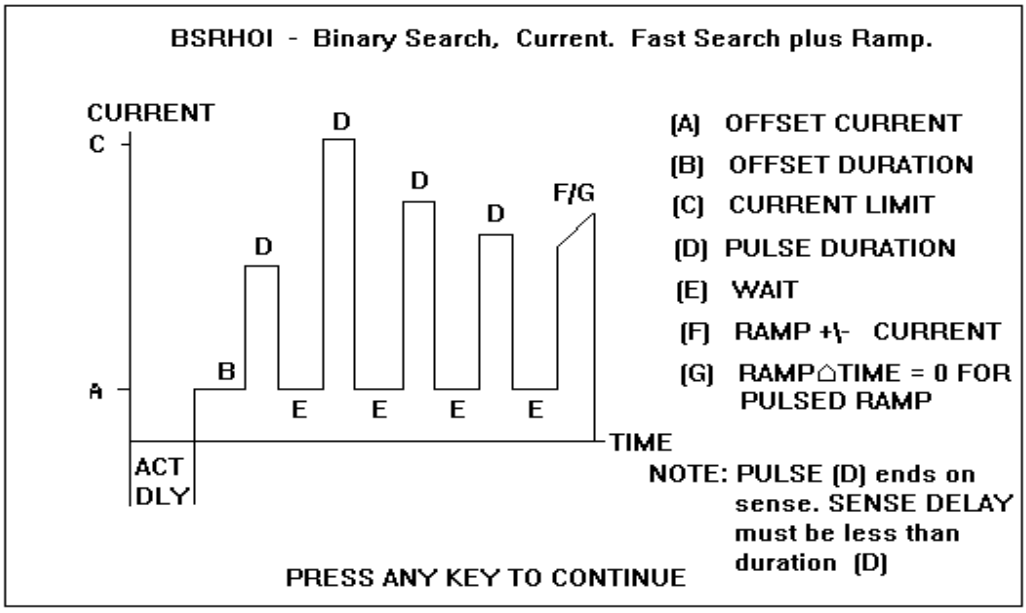


Fig. 8

Appendix
Doble Protest Testing

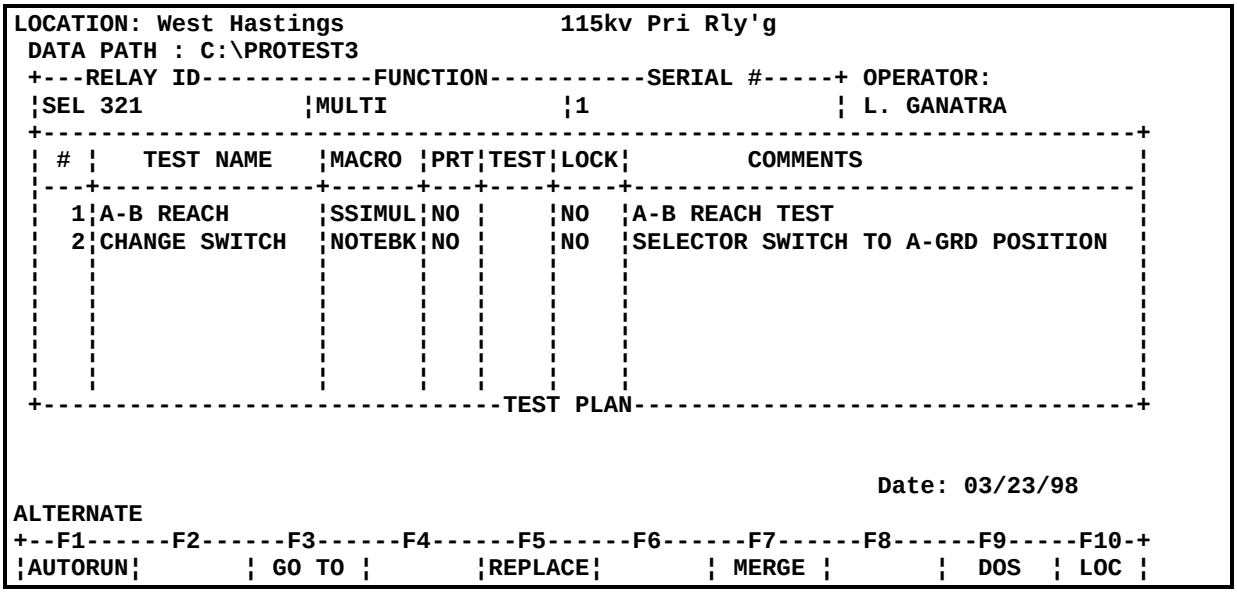


Fig. 9

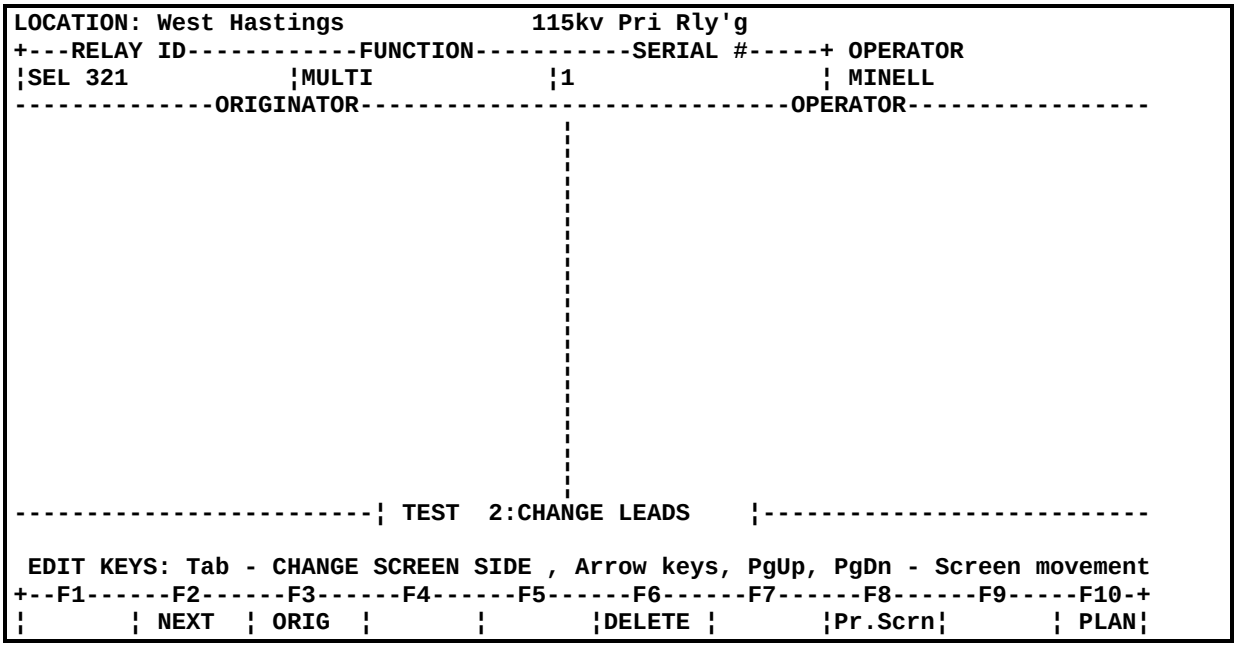


Fig. 10

Appendix
Doble Protest Testing

```
LOCATION: West Hastings                115kv Pri Rly'g
+---RELAY ID-----------FUNCTION----------SERIAL #-----+ OPERATOR  MEM=    77
¦SEL 321          ¦MULTI            ¦1                ¦ MINELL
----------PRESET CONDITIONS--------------------ACTION CONDITIONS-------------
SRC¦CONNECTIONS¦    VALUE    ¦ FREQ ¦                                ¦ SENSE:
ASS+--HI----LO-+-AMPL--PHASE-+--HZ--¦(A)OFFSET VOLTAGE:   70.00  VOLTS¦CONTACTS
VA ¦      ¦     ¦ACTION¦   0.0¦ 60.00¦(B)OFFSET DURATION:  30    CYCLES¦O -> C
VB ¦      ¦     ¦ACTION¦-120.0¦ 60.00¦(C)VOLTAGE LIMIT:     0.00  VOLTS¦
VC ¦      ¦     ¦ 70.00¦-240.0¦ 60.00¦(D)PULSE DURATION:    5    CYCLES¦
I1 ¦      ¦     ¦  5.00¦  45.0¦ 60.00¦(E)WAIT:             10    CYCLES¦
   ¦      ¦     ¦      ¦      ¦      ¦(F)+/-□ VOLTAGE:     -0.100 VOLTS¦
   ¦      ¦     ¦      ¦      ¦      ¦(G)□ TIME :           5    CYCLES¦
BAT¦      ¦     ¦  0.00+-------------¦                                   ¦
   ¦      ¦     ¦      ¦ProTesT MACRO¦                                   ¦
   ¦      ¦     ¦      ¦             ¦                                   ¦
MA ¦      ¦     ¦SENSE ¦   BSRHOV    ¦                                   ¦
-----------------------------------¦                                   ¦
PRESET: DELAY  0.0SEC-ZERO X: SYSTEM¦                                   ¦
ACTION: DELAY  0.0SEC-ZERO X: SYSTEM¦EXPECTED:   0.00 VOLTS + 0%  - 0%¦
 SENSE: DELAY    0CY.-DURATION  0MS.¦  ACTUAL:   0.00       ERR   0.0%¦
-------------------------¦ TEST   1:A-B REACH      ¦-------------------------
   NO RESULTS HAVE BEEN STORED FOR THIS TEST

+--F1------F2------F3------F4------F5------F6------F7------F8------F9-----F10-+
¦ RUN   ¦ NEXT  ¦ ORIG  ¦ NOTES ¦ DATA  ¦ PLOT  ¦       ¦Pr.Scrn¦       ¦ PLAN¦
```

Fig. 11

Appendix
Doble Protest Testing

```
LOCATION: West Hastings                115kv Pri Rly'g
+---RELAY ID------------FUNCTION-----------SERIAL #-----+ OPERATOR  MEM=   104
¦SEL 321           ¦MULTI             ¦1                ¦ L. GANATRA
----------  INSTRUCTIONS   --------------------PROGRAM PARAMETERS-------------
                                      ¦
THIS MACRO EXECUTES STATE SIMULATOR.  ¦
                                      ¦
                                      ¦
                                      ¦
                                      ¦      STATE SIMULATOR TIMER RESULTS
                                      ¦
                                      ¦EXPECTED 1:     0.00       + 0%  - 0%
BAT                                   ¦    ACTUAL:     0.00  ERR      0.0%
                                      ¦
                                      ¦EXPECTED 2:     0.00       + 0%  - 0%
TIMER UNITS:    MSEC                  ¦    ACTUAL:     0.00  ERR      0.0%
                                      ¦
                                      ¦EXPECTED 3:     0.00       + 0%  - 0%
                                      ¦    ACTUAL:     0.00  ERR      0.0%
                                      ¦
-------------------------¦ TEST   1:A-B REACH      ¦---------------------------
   NO RESULTS HAVE BEEN STORED FOR THIS TEST

+--F1------F2------F3------F4------F5------F6------F7------F8------F9-----F10-+
¦ RUN   ¦ NEXT  ¦ USER  ¦ NOTES ¦ DATA  ¦ PLOT  ¦       ¦Pr.Scrn¦REMOVE ¦ PLAN¦
```

Appendix
Doble Protest Testing

Fig. 12

Appendix
Doble Protest Testing

```
FILE: PT$SIMUL       TEST: Simulation 1                          PAGE  1 of  1
+-------------------------------------------------------------------------------+
| SRC | Pre-Fault              | Fault                  | Post-Fault             |
+-----+--AMPL---PHASE----FREQ-+--AMPL---PHASE----FREQ-+--AMPL---PHASE----FREQ--|
|VA   |69.3   |0      |60     |20     |0      |60     |69.3   |0      |60      |
|VB   |69.3   |-120   |60     |69.3   |-120   |60     |69.3   |-120   |60      |
|VC   |69.3   |-240   |60     |69.3   |-240   |60     |69.3   |-240   |60      |
|H1   |1      |-10    |60     |20     |-75    |60     |0      |0      |60      |
|     |       |       |       |       |       |       |       |       |        |
|     |       |       |       |       |       |       |       |       |        |
|     |       |       |       |       |       |       |       |       |        |
|     |       |       |       |       |       |       |       |       |        |
|     |       |       |       |       |       |       |       |       |        |
|     |       |       |       |       |       |       |       |       |        |
|     |       |       |       |       |       |       |       |       |        |
|     |       |       |       |       |       |       |       |       |        |
|     |       |       |       |       |       |       |       |       |        |
+-----+-----------------------+-----------------------+------------------------+
|TIME |   120 CY TIME         |    20 CY TIME         |    60 CY TIME          |
+-------------------------------------------------------------------------------+
| BATTERY SIM: 0    V  | TIMER VA: Fault           | TIMER   :                 |
| ZERO CROSSING:SYSTEM | 0      MS CONTACT O -> C  |                           |
MESSAGE: Please Wait... Requesting Status.           TIMER   :                  |
|                      |                           |                           |
+--F1------F2------F3------F4------F5------F6------- F7----F8------F9-----F10--|
|  Run  |       |Insert |       |  Add  |Delete | Copy  | Print |Status | Dir   |
```

Fig. 13

Appendix
Doble Protest Testing

Electrical Functional Testing of Solid State Distance Relaying System Including Power Swing Block

1. Purpose

To describe the method of Electrical Functional testing to verify the reliable performance of the Solid State Distance Relaying System (including power swing blocking of reclosing) based on the specified settings and applications. The devices under test include, but are not limited to the following:

	Function Number	Relay Type	Instruction Description	Leaflets
1.1.	21S1	SKDU	Zone1-Phase Distance	
1.2.	21S2	SKDU	Zone2-Phase Distance	
1.3.	21GS1	SDGU – 1/7	Zone1-Ground Distance	
1.4.	21GS2	SDGU – 1/6	Zone2-Ground Distance	
1.5.	67GTS	IRD-9	Ground Time Overcurrent	
1.6.	68S	SDBU – 2/SKSU	Out of Step/Power Swing	
1.7.	50S, 50SH	SIU	Overcurrent Fault Detector & Inst. hi set ele.	
1.8.	95S	SRU	Static Relay Unit (Contains various Timers and other Logic)	

2. Definitions

2.1.
2.2.

3. Equipment Needed

3.1. Test Equipment

3.1.1. Doble Test Set - containing three (3) phase Voltage and one(1) high Current units at minimum.
3.1.2. Lap Top Computer
3.1.3. Digital Multimeter
3.1.4. Oscilloscope
3.1.5. Switch Box

3.2. Software

3.2.1. Doble Protest program.
3.2.1.1.Relay System Test Plan for the Solid State Distance Scheme

3.3. Other

3.3.1. Equipment Tag
3.3.2. Spare Capacitors, Resistors, transistors and diodes for SKDU, SDGU and SDBU Relays.

4. References

4.1. Doble Protest Testing Procedure RLY - 4.3.01.01
4.2. M&R
4.3. A.C. & D.C. Schematics
4.4. Relay Test Sheets
4.5. Xcel Energy Safety Manual
4.6. Xcel Energy Control Standard Book

5. Procedure

5.1. Precautions

5.1.1. **Identify the panel and the devices which will be tested** (refer to the Schematic, Relay Test Sheets and RFO). Set the Doble Test equipment in front or near the panel. _____

5.1.2. **Call DISPATCHER for CLEARANCE**. _____

5.1.3. **Turn off all 97 switches** for PROPER CLEARANCE. _____

5.1.4. **Open ALL appropriate trip switches- COUNT TRIP SWITCHES OPENED. Compare to the schematics and Trip Switch Index.** _____

SAFETY NOTE
EXTREME CAUTION MUST BE TAKEN WHEN ISOLATING CT'S. TAKE CARE TO OBSERVE ALL SAFETY PRECAUTIONS WHILE PERFORMING STEPS (5.1.5 – 5.1.8)!!

CAUTION: High Voltage could occur if CT's are opened while connected to an energized circuit.

5.1.5. Isolate relays to be tested by opening the CT blocking bar or flexitest shorting switches associated with the correct line relays according to the A.C. schematic. _____

5.1.6. *Note: Be sure to open each CT isolating or shorting switch* ***SLOWLY; ONE-AT-TIME, making sure that the AC input current to the panel is shorted by the switch as you open it.*** Take your time and refer to the A.C. Schematic. _____

5.1.7. Isolate A.C. potential source to the relay system being tested. _____

Methods of isolation:

1. **Switches**: Verify with a voltmeter that the potential is present on the blades of the potential isolating switches and **NOT ON THE CLIPS.**
2. **Fuse Blocks**: Verify with a voltmeter that the potential is present on the top fuse block clips and **NOT ON THE BOTTOM.**
3. **Panel Fuses**: Verify with a voltmeter that the potential is on the front terminal next to the panel and **NOT TO THE BACK.**

5.1.8. Connect potential test leads to the relay side of isolating source. _____

5.1.9. Verify the DC control voltage to the relay system is as shown in D.C. schematic. _____

5.2. Instructions

5.2.1. *Connect* Doble F2xxx units as you would normally do for testing of the relay scheme. _____

5.2.2. *Connect* COM1 RS232 serial port (9 pin male) of your laptop to RS232 port (25 pin female) of a Doble unit. 3 - ADT is the cable to be used connecting the two ports. _____

5.2.3. Connect the Doble test set to the isolated input current and voltage terminals. _____
(Sensing leads from Doble test set should be across the entire tripping path and include all relays under test to ensure the complete continuity for test plan simulation.)

5.2.4. Verify the test plan for the system _____

5.2.5. Test the relay system as per Doble Protest Test Plan. _____

5.2.6. The test plan makes use of Doble State Simulator Macro. The State Simulator simulates the fault condition from normal operation. The fault currents and voltages used were derived from previously run fault studies in CAPE. Various types of internal and external faults are simulated. Fault currents and voltages are taken from the simulation and incorporated in the test plan. The test plan will indicate what relays will operate in which test condition. If there is any discrepancy, make a note. _____

5.2.7. If any of the relays fails to perform as expected, check the relay independent of the SRU to determine whether the problem lies in the SRU or the relay. If it lies in the relay, retest the relay in question using the values from the Relay Test Sheet. _____

5.2.8. Contact a Relay Engineer and ask the engineer to verify the settings. The engineer should also be requested to verify the test currents and voltages. If the engineer confirms that everything is correct, do not change anything if the relay operates correctly at those values. The Relay is in good operating condition. The Engineer has the responsibility to check the fault study at a later time. _____

5.2.9. If the relay does not operate at the test sheet values and if the Relay Engineer finds the test sheet values are wrong, then get new values and retest the relay. _____

5.2.10. **If the relay and/or SRU appears to be functioning incorrectly, it may require recalibration or repair. Please make a note of the problem and inform the Scheduler to schedule the repair as soon as possible. However, please proceed with testing the other functions instead of attempting to repair the problem.** _____

5.3. Close-out

After testing is completed successfully, before clearing with the dispatcher, follow the items below:

5.3.1. Remove all Doble test leads from the relay inputs. _____

5.3.2. Verify all other wires have been removed from the relay system. _____

5.3.3. Remove all jumpers, if there are any _____

5.3.4. Verify all potential fuses have been installed. _____

5.3.5. Remove any current isolating devices and close all Potential and Current switches(e.g. FT switch). *Verify with a A.C. voltmeter that all potential inputs at the relays are energized.* Put the FT switch cover. _____

5.3.6. Turn on all 98 switches. _____

5.3.7. Close all RTS NEG. trip switches, one at a time, and verify all relay targets are reset. _____

5.3.8. Close the remaining trip switches, one at a time. _____

5.3.9. Clear with dispatcher and inform that 97 switches are in the **ON** position. _____

Transformer Detailed Inspection

1. Purpose

The purpose of this procedure is to provide instructions for the testing and maintenance of the Power and Distribution Transformers for Mechanical and Electrical Integrity.

2. Definitions

2.1. **Testing and repairs** includes the following:

2.1.1. Cleaning devices.

2.1.2. Tightening and re-gasketing on manhole cover, bushing, etc.

2.1.3. Replacement of failed parts with identical parts is allowable.

2.1.4. Measuring and recording “as found” and “as left” conditions.

Note: Normal repairs do not include modifications of relays or control schemes.

2.2. **"As Found"** measurements are measurements made before any cleaning, adjusting, or repairing is done on a device.

2.3. **"As Left"** measurements are measurements made after cleaning, adjusting, and repairing have been completed on a device.

2.4. **Bypass**

Any device which blocks a component out of service or which prevents it from performing its intended function. Example: An electrical jumper or lifted wires.

3. Equipment Needed

3.1. Properly stocked maintenance vehicle.

4. References

4.1. Electrical

4.1.1. Transformer Instruction Book.

4.1.2. Single-line diagrams.

4.1.3. Three-line diagrams.

4.2. Standards

4.2.1. ANSI-C57.12.00-1993, General requirements for Liquid-Immersed Distribution, Power and Regulating Transformers.

5. Procedure

5.1. Precautions

5.1.1. Maintenance provider personnel shall take necessary precautions to prevent accidental contact with high voltage equipment as per the Xcel Energy Safety Manual.

5.1.2. Flammable solvents and cleaning fluids shall be kept in approved containers. The containers shall be labeled ***FLAMMABLE*** and shall have the type of material indicated on them per **(MSDS).**

5.1.3. All material must be on the approved list of Xcel Energy Hazardous Material Procurement Program.

5.1.4. Maintenance provider personnel shall take necessary precautions for the following:

5.1.4.1. Shall take necessary precautions to properly ground equipment to discharge capacitive charges induced through service or testing.

5.1.4.2. Shall take necessary precautions never to touch any leads, terminal, bushings, etc., with test equipment energized. A transformer with a high turn to turn ratio transforms very small input voltages into dangerously high output voltages.

5.1.4.3. Post **"Danger High Voltage"** signs as necessary and barricade appropriate areas on top of the transformer and the ground for personnel protection.

5.1.4.4. Covers or fittings shall not be opened unless zero gauge pressure exists inside the unit. Always relieve internal pressures slowly through valves.

5.1.5. Transformer oil must always be handled as flammable liquid. Closed transformer and load tap changer tanks may, under some conditions, accumulate explosive gases, and oil handling procedures may generate static electricity. Proper grounding is imperative.

5.1.6. Refer to the manufacture's instruction manual for test requirements and as certain manufactures may recommend additional tests which may not be included in the procedure.

5.1.7. Write N/A on the transformer Test Report for the tests not applicable to the transformer being tested.

5.2. Test

NOTE: Use pen in completing all forms. Results of the following steps shall be documented on Transformer and LTC Detailed Inspection List Pages. Each step of these instructions shall be initialed prior to starting the next step.

5.2.1. If required, Verify Supervisor has authorized work to start. _____

5.2.2. Tailgate (See tailgate check-off list). _____

5.2.3. Inspect the transformer and accessories for external physical damage to paint finish, tanks, radiators, bushings and any indications of leaks. Record "as found" and "as left" condition in comment section on **Transformer and LTC Detailed Inspection List**. _____

5.2.4. Check oil levels on Main Tank, Conservator Tank, Load Tap Changer and Bushings. Record "as found" and "as left" oil levels in comment section on **Transformer and LTC Detailed Inspection List.** _____

5.2.5. Inspect and ensure that the case and core assembly of the transformer are permanently and adequately grounded. Record "as found" and "as left" condition in comment section on **Transformer and LTC Detailed Inspection List.** _____

5.2.6. Inspect and ensure that ground resistors are properly installed and free of damage. Record "as found" and "as left" condition in comment section on **Transformer and LTC Detailed Inspection List.** _____

5.2.7. Inspect fans for vibration and condition of blade. Ensure that fans motor are lubricated and that connections are in good working order. Record "as found" and "as left" condition in comment section on **Transformer and LTC Detailed Inspection List.** _____

5.2.8. Inspect pumps for oil leaks, vibration, check flow gauge rotation and that connections are in good working order. Record "as found" and "as left" condition in comment section on **Transformer and LTC Detailed Inspection List.** _____

5.2.9. Inspect Control Cabinet for moisture and condition of door gaskets. Check relay coils for excessive noise, discoloring, burning odor and charred wiring, check connections for tightness and check heaters. Record "as found" and "as left" condition in comment section on **Transformer and LTC Detailed Inspection List.** _____

5.3. Close-out

5.3.1. Complete the **Transformer and LTC Detailed Inspection List.** Record all required information including "As Found" conditions that may have prevented proper operation of the transformer. _____

5.3.2. Ensure **all data forms** are completed and attached. _____

5.3.3. Reviewed by System Engineer. _____

TRANSFORMERS AND LTC DETAILED INSPECTION LIST

(attach as many sheets as necessary)

Substation _____
Transformer # _____

1) **Inform – Systems Operation, Trouble Foreman or Local Dispatch, that you are in the substation performing maintenance.**

	Condition	Needs Attn.	Remarks
2) Visually inspect general condition of equipment:			
a) Bushings (oil levels, broken etc.)	_____	_____	_____
b) Oil levels (main tank and LTC)	_____	_____	_____
c) Control cabinet (fuses, heaters, thermostats etc.)	_____	_____	_____
d) Is the TR schematic in the control cabinet?	_____	_____	_____
e) Oil leaks	_____	_____	_____
f) Grounding connections	_____	_____	_____
g) Operate fans and pumps (lubricate)	_____	_____	_____
h) Change Nitrogen bottle if under 600 psi	_____	_____	_____
i) Check for leaks (using soap suds)	_____	_____	_____
j) Sample oil if due	_____	_____	_____
k) Note any conditions requiring an outage to repair	_____	_____	_____
3) Take oil dielectric on all LTC's with Vac bottle. (If test shows heavy carbon and the dielectric is <25kV, record remarks.)	_____	_____	_____
4) Take gas-in-oil on all LTC's without Vac Bottle (Bring sample to CSC testing laboratory)	_____	_____	_____

Note any conditions requiring an outage to repair. Remove defective fans for repair.

Comments:

_____
_____
_____
_____
_____

Complete inspection sheets and return to office.

TRANSFORMER DETAILED INSPECTION

Transformer Electrical Testing

1. Purpose

The purpose of this procedure is to provide instructions for the testing of Power and Distribution Transformers for Mechanical and Electrical Integrity.

2. Definitions

2.1. **Testing and repairs** includes the following:
- 2.1.1. Cleaning devices.
- 2.1.2. Measuring and recording “as found” and “as left” conditions.

2.2. **As Found"** measurements are measurements made before any cleaning, adjusting, or repairing is done on a device.

2.3. **"As Left"** measurements are measurements made after cleaning, adjusting, and repairing have been completed on a device.

2.4. **Bypass**
Any device which blocks a component out of service or which prevents it from performing its intended function. Example: An electrical jumper or lifted wires.

2.5. **Maintenance Provider Technician**
That individual, trained and qualified in accordance with appropriate testing instructions and procedures, who has been designated by the Supervisor as having the responsibility for the correct performance of the work required by this procedure.

3. Equipment Needed

3.1. **“Danger High Voltage”** signs and barricades
3.2. Doble Automated Insulation Analyzer (M4000)
3.3. Transformer turns ratio test set (Biddle)
3.4. Transformer Ohmmeter Test set (Multi-Amp)
3.5. Hypotronics Oil Dielectric Test set with D1816 test cell (when required)
3.6. Portable grounds
3.7. Liquid-insulator cell
3.8. Oil sample bottles and Test Lab Data Sheets (as needed)
3.9. Disk or M4000 loaded with all nameplate information on the transformer, LTC, bushings, and surge arresters. This information is available directly from the Office System via modem.
3.10. Doble leakage reactance test set (as required)
3.11. Core demagnetization equipment
3.12. Megger

4. References

4.1. Electrical

4.1.1. Maintenance File(s) (previous Doble test and maintenance data)
4.1.2. Nameplate
4.1.3. Doble Automated insulation Analyzer Instruction Book
4.1.4. Schematics or diagram of control circuit.
4.1.5. Single-line diagrams.
4.1.6. Three-line diagrams.
4.1.7. Relay and meter diagrams.
4.1.8. Procedure for demagnetizing the core.
4.1.9. Procedure for dielectric oil breakdown testing with D1816 cup.
4.1.10. Manufacturer's instruction manual.

4.2. Standards

4.2.1. ANSI-C57.12.00-1980, General requirements for Liquid-Immersed Distribution, Power and Regulating Transformers.
4.2.2. ANSI-C57.12.90-1980, Guide for short-circuit testing for Liquid-Immersed Distribution, Power and Regulating Transformers.
4.2.3. ANSI-21-1976, General Requirements and Test Procedures for Outdoor Apparatus Bushings.

5. Procedure

5.1. Precautions

5.1.1. Verify station operator (maintenance crew) has isolated the transformer and operations has authorized work to start.

5.1.2. Maintenance provider personnel shall take necessary precautions to prevent accidental contact with high voltage equipment as per the Xcel Energy Safety Manual.

5.1.3. Flammable solvents and cleaning fluids shall be kept in approved containers. The containers shall be labeled ***FLAMMABLE*** and shall have the type of material indicated on them per **(MSDS.)**

5.1.4. All material must be on the approved list of Xcel Energy Hazardous Material Procurement Program.

5.1.5. Maintenance provider personnel shall take necessary precautions for the following:

1. Shall take necessary precautions to properly ground equipment to discharge capacitive charges induced through service or testing.

2. Shall take necessary precautions never to touch any leads, terminals, bushings, etc., with test equipment energized. A transformer with a high turn to turn ratio transforms very small input voltages into dangerously high output voltages.
3. Post **"Danger High Voltage"** signs as necessary and barricade appropriate areas on top of the transformer and the ground for personnel protection.

5.1.6. Refer to the manufacture's instruction manual for test requirements, manufactures may recommend additional tests which may not be included in the procedure.

5.1.7. Write N/A on the transformer Test Report for the tests not applicable to the transformer being tested.

5.1.8. After oil processing, you must wait at least 24 hours before performing the electrical tests.

5.2. INSTRUCTIONS

NOTE: Use pen in completing all forms. Results of the following steps shall be documented on Maintenance and Test Report Pages. Each step of these instructions shall be initialed prior to starting the next step.

NOTE: The following procedure covers testing for existing transformers and for new, rebuilt and moved transformers. Mark N/A for tests not applicable to the transformer being tested.

5.2.1. Tailgate (See tailgate check-off list.) _____

5.2.2. Check isolation, post necessary "Danger High Voltage" signs, and ensure that the top of transformer is barricade appropriately. On **existing transformers**, test for dead and place personal grounds on transformer and associated equipment. _____

5.2.3. Record any missing transformer and associated equipment information into Doble Automated Insulation Analyzer and verify information is correct with nameplate data on transformer and associated equipment. _____

5.2.4. Inspect and clean transformer bushings and surge arresters and ensure that they are dry. Record "as found" and "as left" in comment section on **Maintenance and Test Report**. _____

5.2.5. On **existing transformers**, visually inspect and ensure that the case and core assembly of the transformer are permanently and adequately grounded. Record "as found" and "as left" condition in comment section on **Maintenance and Test Report**. _____

5.2.6. **Power Factor**

Perform Power Factor Test using the Doble Automated Insulation Analyzer test set as follows:

1. On **existing transformers**, using the Doble Automated Insulation Analyzer test set, measure the power factor of each winding to ground and between windings (H-G, L-G, T-G, H-L, L-T, T-H) on the running tap. _____
2. On **new, rebuilt and moved transformers**, using the Doble Automated Insulation Analyzer test set, measure the power factor of each winding on the highest NLTC tap and LTC on neutral (if applicable).
3. Winding power factor shall not exceed the acceptable limit specified by the manufacture's instruction book. (XCEL ENERGY's standard is 0.5% on new equipment.) _____
4. Power factor measurements shall be temperature corrected in accordance with the Doble software. _____
5. Save data for uploading to the Office System. _____

5.2.7. **Exciting Current**

On **existing transformers** perform Exciting Current Tests using the Doble Automated Insulation Analyzer Test Set as follows:

1. Using the Doble Automated Insulation Analyzer Test Set, take exciting current test on each winding that the test set is capable of testing. If LTC exists, take exciting current for 16R, 1R, N and 1L. _____
2. Save data for uploading to the Office System. _____

5.2.8. **Transformer Turns Ratio**

On **existing transformers** perform (TTR) Transformer Turns Ratio tests using the Biddle test set as follows:

1. Examine transformer NLTC tap for operating position and check nameplate for correct test connections. Enter the nameplate data on the **Doble M4000 TTR page**. _____
2. Using the transformer turns ratio test set, take the turns ratio measurements on running NLTC tap and data on the **Doble M4000 TTR page**. (If LTC exists, set in neutral position.) _____
3. If LTC exists, with the NLTC on the running tap, test half of the LTC taps (16R – 1L) _____

5.2.9. **Winding Resistance**

Perform Winding Resistance measurements using the Multi-Amp ohmmeter as follows:

1. Examine transformer NLTC tap for operating position and check nameplate for correct test connections. _____
2. On **existing transformers**, using the Transformer Ohmmeter Test set, take the Winding Resistance test on the running NLTC tap and record data on **the Doble M4000 diagnostics page** in a note. _____
3. On **new, rebuilt, and moved transformers**, using the Transformer Ohmmeter Test set, take the Winding Resistance test on each NLTC tap. With LTC (if applicable) test with LTC on neutral and each NLTC tap and with the NLTC on the highest tap (tap A), test half of the LTC taps (16R - 1L) and record data on the **Doble M4000 diagnostics page** in a note. _____

5.2.10. **Bushings**

On **all transformers** perform Bushing Tests using the Doble Automated Insulation Analyzer Test Set as follows:

1. For bushings equipped with capacitance taps: _____
   - Test for capacitance and power factor in UST (ungrounded specimen test) test mode (C1). If C1 test is not rated "G" by DTA, shoot C1 backwards (UST mode test) and Tip-Up test, as needed.
   - Test capacitance tap insulation in GST (ground specimen test) guard, test mode (C2).
2. For bushings not equipped with capacitance taps, measure the Watts loss of the bushing using the "Hot Collar Test" _____
3. Save data for uploading to the Office System. _____

5.2.11. **Surge Arresters**

On all transformers, perform Surge Arrester Test using the Doble Automated Insulation Analyzer Test Set, as follows:

1. Using the Doble Automated Insulation Analyzer Test Set, take overall insulation test on Surge Arrester. If surge arresters are stacked, test each individual surge arrester in the stack. _____
2. Save data for uploading to the Office System. _____

5.2.12. **Oil Power Factor**

On **all transformers**, take insulating oil sample the liquid-insulator cell and take a power factor test. (Test both the main tank oil and the LTC oil when applicable.) **Note:** Sample must be taken under positive pressure, flush sampling valve, drain approximately one quart of oil and discard to ensure sample is not contaminated. Record power factor results on **Doble M4000 diagnostics page.** _____

5.2.13. **Insulating Oil , Karl Fisher, PCB and Gas-In-Oil** (When Required)
On **new, rebuilt, moved transformers and in-service transformers**, take a Karl Fisher, PCB and Gas-In-Oil test and complete the Testing Lab Data Sheet and forward to qualified testing laboratory for analysis, as soon as possible. **Note:** Sample must be taken under positive pressure; flush sampling value, drain approximately one quart of oil and discard to ensure sample is not contaminated. (See oil sampling procedure.) _____

5.2.14. **Dielectric Breakdown Voltage of Insulating Oil** (When Required)
On **new, rebuilt, moved transformers and in-service transformers**, perform the ASTM D1816 test using the Hypotronics Oil Dielectric Test Set. (See oil sampling procedure.) _____

5.2.15. **Megger Core Ground**
Test if the core ground is accessible without opening the transformer. _____

5.3. Close-out

5.3.1. Reconnect any transformer grounds that may have been removed for testing. _____

5.3.2. Remove all temporary jumpers used for testing. On **existing transformers** replace all lifted wires and torque connections. _____

5.3.3. On **existing transformers** Remove all personal safety grounds and barriers from top of transformer and release hold cards with Supervisor. _____

5.3.4. Complete the **Maintenance and Test Report.** Record all required information including "As Found" conditions that may have prevented proper operation of the transformer. _____

5.3.5. Insure **all data forms** are completed and attached. _____

5.3.6. **Return DTA test data via modem** (or disk if the modem is not accessible. _____

5.3.7. Reviewed by Engineer. _____

MAINTENANCE AND TEST REPORT

DATE _____

All initials shall be identified below:

Initial	Name (Print or write legibly)	Title
_____	_____	_____
_____	_____	_____

STATION/UNIT_____ **EQUIPMENT**_____

SERIAL#_____ **PEM#**_____

NAMEPLATE DATA

MANUFACTURER_____ **CLASS**_____

VOLTAGE_____ **MVA**_____ **INST. BOOK**_____

TYPE MAINTENANCE **INITIAL**_____ **MAJOR**_____ **MINOR**_____ **EMERGENCY**_____

WORK DONE (EXPLAIN IN DETAIL)_____

MAINTENANCE AND TEST REPORT

PARTS USED

NOTE: ALL PARTS MUST BE CHARGED OUT OF STOCK SYSTEM

QUANTITY	PART NAME	PART NUMBER	XCEL ENERGY/STOCK NO.

INSTRUMENTS AND CALIBRATION

Instrument Name	Number	Last Calibration	Next Calibration
Transformer Turns Ratio			
Transformer Ohmmeter			
Doble Automated Insulation Analyzer			

Transformer Oil Sampling

1. Purpose

The purpose of this procedure is to provide instructions for the drawing Insulating Oil from Power and Distribution Transformers to determine the quality of the insulating oil.

2. Definitions

2.1. Drawing Insulating Oil includes the following:

2.1.1. Cleaning the sampling valve before taking the sample.

2.1.2. Draining approximately a quart of insulating oil before taking the sample

2.1.3. Taking the sample and sealing the sample container securely and filling out the Testing Lab Test Sheet.

2.1.4. Forwarding the sample to laboratory as soon as possible for testing.

3. Equipment Needed

3.1. Hypertronics Oil Dielectric Test set
3.2. D1816 cup or D877 cup (as required)
3.3. Sampling syringe, stopcocks and tubing
3.4. Plastic 1-quart oil sample bottles
3.5. Special sample bottle with aluminum foil gasket for Karl Fisher test
3.6. Special PCB sample bottle
3.7. Test Lab Data sheets and labels

4. References

4.1. Evaluation of Transformer Insulating Oil

4.1.1. Transformer Instruction Book.

4.1.2. A Guide to Transformer Maintenance by S.D.Myers

4.1.3. Corporate PCB and Oil Management Plan.

4.2. Standards

4.2.1. ASTM Book of Standards, Part 40, D-974, P. 333 (1980 Edition)

4.2.2. ASTM D-877 Dielectric Breakdown Strength, ASTM D-947 Neut. Number, ASTM D-971 IFT, ASTM Specific Gravity, is a laboratory test from plastic quart bottle with Insulating Oil sample.

4.2.3. ASTM D-1816 Dielectric Breakdown Voltage is a field test using the Hypotronics Oil Dielectric Test set.

4.2.4. ASTM D-924 Power Factor at 25 degrees C is a test done with a liquid-insulator cell tester, using a Doble Automated Insulator Analyzer and taking a (UST) Ungrounded Specimen Test at 10KV.

4.2.5. ASTM D-1533 Karl Fischer is a laboratory test used to determine the total moisture content in parts per million (PPM).

4.2.6. ASTM D-3612 Gas-in Oil is a laboratory test revealing PPM of combustible gasses dissolved in the oil.

4.2.7. ASTM D-923-81 and classified per 40 CFR 761 PCB (POLYCHLORINATED BIPHENYLS) is a laboratory test to identify PCB contaminated oil in equipment.

5. Procedure

5.1. Precautions

5.1.1. Maintenance provider personnel shall take necessary precautions to prevent accidental contact with high voltage equipment as per the Xcel Energy Safety Manual.

5.1.2. Flammable solvents and cleaning fluids shall be kept in approved containers. The containers shall be labeled ***FLAMMABLE*** and shall have the type of material indicated on them per **(MSDS).**

5.1.3. All material must be on the approved list of Xcel Energy Hazardous Material Procurement Program.

5.1.4. Maintenance provider personnel shall take necessary precautions for the following:

1. When sampling oil in energized equipment it is essential that the oil level in the equipment does not fall below the minimum operating level.

2. Take sample from a unit only under positive pressure.

3. Must flush sampling value before taking sample. Drain approximately one quart of insulating oil and discard to ensure oil sample is not contaminated

4. Ensure that oil sample is protected from sunlight.

5. Ensure that Testing Lab Data Sheet is completed correctly and sample is forwarded to testing laboratory as soon as possible.

6. Write N/A on oil sample tests not taken in this procedure.

5.2. Instructions

5.2.1. Verify that unit information is correct on Testing Laboratory Data Sheet for unit being tested. _____

5.2.2. Fill in blanks on Testing Laboratory Data Sheet for oil temp., winding temp., ambient temp., date sampled, gallons of oil and what type of test is being taken. _____

5.2.3. Verify that the unit is under positive pressure before taking oil sample. _____

5.2.4. Taking an **Insulating Oil** sample using a **plastic quart bottle:**

1. Wipe clean the sampling valve before removing plug. _____
2. Drain approximately one quart of insulating oil before actual oil sample is taken to ensure sampling value is clean. _____
3. Thoroughly rinse plastic quart bottle with insulating oil before drawing oil sample. _____
4. Draw oil sample, seal sample container securely and attach Testing Lab Test Report. _____
5. The sampling valve should be wiped clean and adequately sealed. _____
6. The oil sample should be protected from sunlight and forwarded to the laboratory for testing. _____

5.2.5. Taking **Karl Fischer** oil sample:

1. Wipe clean the sampling valve before removing plug. _____
2. Drain approximately a quart of insulating oil before actual oil sample is taken to ensure sampling valve is clean. _____
3. Using special bottle with aluminum foil gasket supplied by testing laboratory, open bottle and insert clean plastic tube so end goes to bottom of bottle and oil fills from bottom. Allow bottle to overflow, then secure lid by putting aluminum foil over opening, install cap and tighten. **Attach Testing Lab Test Report.** _____

4. The sampling valve should be wiped clean and adequately sealed. _____

5. The oil sample should be protected from sunlight and forward to the laboratory for testing. _____

5.2.6. Taking a **Gas-in-Oil** oil sample:

1. Wipe clean the sampling valve before removing plug. _____

2. Drain approximately one quart of insulating oil before actual oil sample is taken to ensure sampling value is clean. _____

3. With the Tygon tubing connected to the small sampling valve or through the hole in the drain-valve plug, adjust the valve for a gentle flow of oil through the tubing. Connect the syringe to the tubing with the syringe stopcock open to permit flushing of the stopcock. _____

   Note: Syringe should be filled to 50 cc (twice) and all oil discharged. This is for cleaning the syringe. The third oil fill is the test sample

4. Turn the stopcock slowly to the open position (handle in line with the flushing port) and allow 50 cc of oil to enter the syringe. Immediately close the stopcock (handle towards the syringe) and separate from the tubing. Allow the oil to continue to flow from the tubing. _____

5. With the syringe vertical (stopcock up, handle away from the syringe), eject any air bubble and depress the syringe piston to bottom. Close the stopcock (handle toward the syringe). _____

6. The syringe, bubble-free and with its dead volume filled with oil, is now reconnected to the tubing. Open the stopcock (handle in line with flushing port) and allow oil pressure to push the piston back until the syringe is filled to approximately the 50 cc mark. Note: Do not pull the piston manually since this can result in bubble formation. _____

7. Close the stopcock (handle toward syringe) and separate it from tubing and inspect for air bubbles. If air is present,

discharge oil with syringe vertical (stopcock) up, handle away from the syringe and obtain another sample. _____

8. The oil sample should be protected from sunlight. _____

9. The sampling valve should be wiped clean and adequately sealed. _____

10. Attach the completed Testing Lab Test Report and forward to laboratory for testing as soon as possible. _____

5.2.7. Taking a **PCB (Polychlorinated Biphenyls**) oil sample:

1. Wipe clean the sampling valve before removing plug. _____

2. Drain approximately one quart of insulating oil before actual oil sample is taken to ensure sampling valve is clean. The oil must be handled as PCB-contaminated and disposed of accordingly. **Note: Do not use plastic tubing for sampling.** _____

3. Use special PCB oil sample bottles and special labels with a LT number assigned from Testing Laboratories for taking PCB sample. _____

4. Fill the bottle at least half-full and cap tightly. _____

5. The sampling valve should be wiped clean and adequately sealed. _____

6. Place the label on the sample bottle, along with the Testing Lab Test Report and forward to laboratory for analysis. _____

5.2.8. Taking a **Dielectric Breakdown Voltage** test:

The preferred test method is the **ASTM D1816** test which is more sensitive to moisture and other contaminants. This should be used for all **non** free-breathing devices. When a transformer or LTC compartment is free-breathing, use the D877 test.

Note: Never use the D1816 test for new oil or transformers that have never been energized. This includes bulk oil from tankers, barrels, etc.

1. Set spacing of electrode with 0.040 inches gap gauge. _____

2. Rinse cup a minimum of 2 times with specimen to be tested _____

3. Examine electrode for pitting and contamination. _____

4. The specimen should never be tested below 20 C. If the specimen temperature is below 20 C the specimen should be warmed up to 20 C. _____

5. Set the Rate of Rise Selector Switch on the Hypotronics Oil Dielectric Test Set to 500 VPS/Dl 816 _____

6. After filling cup specimen should be placed in test set with stirrer motor plugged in and set turned on. Allow specimen to sit at least 3 minutes before testing with 1 minute intervals between tests (shots.) _____

7. Take five shots of the specimen. _____

8. To calculate the standard deviation of the five breakdown voltages subtract the lowest voltage reading from the highest voltage reading, multiply this result by 3 if this value is greater than the 2nd lowest voltage reading your sample exceeds the standard deviation. Go to the next step. Otherwise, take the average of the 5 shots. This is the dielectric breakdown voltage of the specimen. _____

9. If the sample exceeds the standard deviation, take five more shots. The dielectric breakdown voltage is the average of all 10 shots. _____

NOTE: If you get 2 excessively low shots in a row and you suspect a contaminated sample, retake the sample.

10. If after repeated (two out of five) low readings, rinse the cup with kerosene, wipe dry with lint free rag and repeat test. _____

11. SUGGESTED LIMITS FOR CONTINUED USE OF SERVICE-AGED INSULATING OIL (GROUPED BY VOLTAGE CLASS)

FOR 0.04 GAP

<= 69 kV: 23KV
69 - 288KV: 26KV
>345KV: 26KV

12. After testing is complete leave good oil in test cell for storage. _____

5.3. Close-out

5.3.1. Ensure **all data forms** are completed and attached. _____

5.3.2. Reviewed by Engineer. _____

Preventive Maintenance Plan for Wheaton Generating Plant

Wheaton Generation Plant Preventative Maintenance Plan Description:

Gas Turbine inspection and maintenance at Xcel Energy is based on Original Equipment Manufacturers (OEM) recommendations and operating experience, coupled with sound engineering judgment. OEM guidance for frequency of inspection is based on starts and/or hours of operation dependent upon the frequency of operation of the gas turbines. For gas turbines that frequently start with low operating hours, maintenance and inspections are typically performed on a total number of starts basis. For gas turbines operating continuously for long periods of time with few starts, operating hours dictate the frequency of inspection and maintenance.

Xcel Energy's gas turbines at Wheaton are operated as peaking plants. That is, the units are only run during peak electricity demand conditions. These operating periods are typically in the 4 to 8 hour range. Consequently, Xcel Energy chooses to monitor the number of starts for a gas turbine as a means to determine proper maintenance and inspection intervals.

Operator Logs are maintained to document the number of starts for a gas turbine at each site. Xcel Energy personnel monitor the status of each gas turbine using the logs and determine the frequency of necessary maintenance for each gas turbine.

During operation of the gas turbines, operators periodically inspect the units, take readings and monitor for problems. These informal inspections provide for early detection of problems, mostly minor in severity, and allow for corrective action on an as needed basis.

Site Description:

Xcel Energy's Wheaton Generating Facility is a 6 unit facility with a winter Urge capacity of approximately 440 MW and a summer Urge capacity of approximately 345 MW.

The Wheaton facility has four General Electric Frame 7001 Model B gas turbines and two Westinghouse 501 AA gas turbines. The maintenance and inspection requirements for these two types of units differ by manufacturer and are based on each manufacturers recommendations for frequency and scope. Specific maintenance and inspection frequencies are listed in the Maintenance Frequency Table on page 4.

Inspection Plan:

I. Gas Turbine Inspection

A. Maintenance and Inspection Activities

NOTE: All inspections are performed based on published Original Equipment Manufacturer (OEM) recommendations and inspection criteria, unit performance trends, and engineering judgment.

1. Normal Operation – During normal operation, operators inspect the gas turbines for evidence of developing problems. Any identified problems are addressed appropriately. Routine maintenance items (e.g. filter replacement, oil replacement, etc.) are completed when indications warrant (e.g. filter differential pressure, oil sample test results, etc.) or at manufacturer recommended intervals.

2. Combustion Inspection – This activity involves removal and repair or replacement of fuel nozzles, combustion liners, transition pieces and crossfire tubes. While these components are removed from the gas turbine, accessible portions of the turbine can be visually inspected for indications of excessive wear.

3. Hot Gas Path Inspection – This inspection includes a complete combustion inspection (as described above) as well as the removal of the top half of the turbine case to allow for inspection of the turbine nozzle and turbine buckets.

4. Major Inspection – Inspection of all major components of the gas turbine that are subject to wear during normal turbine operation. This inspection includes such items as: turbine casings, shrouds, buckets, seals, diaphragms, compressor and air inlet. In addition the activities of the combustion inspection and the hot gas path inspection are also performed.

B. Maintenance Frequencies

1. Frequency of maintenance is determined by the number of starts. Machines that operate for short durations experience the most wear during start-up sequences when temperature fluctuations are the most severe and the stress of thermal cycling is most significant. See the Table below for the OEM recommended frequency of maintenance and inspection activities.

Maintenance Frequency*				
Manufacturer – Unit	Fuel Nozzle Inspection	Combustion Inspection	Hot Gas Path	Major Overhaul
General Electric Frame 7B	N/A	300 starts	600 starts	1200 starts
Westinghouse 501AA	100 starts	300 starts	600 starts	1600 starts

Table 1

* Starts are defined as only those that are successful starts or fired aborts; in other words only those starts that actually introduce heat into the combustion section shall be counted as starts for the purpose of determine maintenance frequency.

2. Any indications of significant operating problems will be evaluated using sound engineering judgment. Maintenance work deemed necessary is performed on an as needed basis, even if the maintenance will occur sooner than the recommended frequencies shown above.

3. The OEM recommended number of starts is strongly considered when determining maintenance intervals. Trending of operational performance and engineering judgment are also used when determining maintenance frequency. Therefore, maintenance inspection and outage frequency may differ from the OEM recommendations based on unit performance and engineering judgment.

II. Gas Turbine Rating

A. Operating performance, generator availability and reliability will be tracked via the National Electric Reliability Council (NERC) and Generator Availability Data System (GADS) requirements. Xcel Energy utilizes the MicroGads software as a database for handling this data. Individual unit data is reviewed periodically to determine adverse trends and identify generating units performing below acceptable levels.

III. Corrective Action Schedule

A. Table I of Section I details the manufacturer's schedules for corrective action for their gas turbines. During the periodic inspections (i.e. combustion, hot gas, major) identified problems are corrected.

B. Budgeting – Annual budgets are developed based on operating histories. Each unit's current status compared to the inspection schedule identified in the Maintenance Frequency table is considered. Those units with impending inspections per the schedule are identified and funding is requested via the Xcel Energy budgeting process.

IV. Record Keeping

A. Maintenance records are maintained on-site of the inspection results for each gas turbine.

B. Generator availability data is tracked and entered on a monthly basis in the MicroGads system. This data is used to trend gas turbine performance and to budget for maintenance activities.

V. Outage Information Exchange

A. PSC-113.0607 requires utilities to share planned outage information for the coming year. This exchange of information will be facilitated through the local reliability councils and/or through participation in a regional transmission organization (RTO) such as the MISO (Midwest Independent System Operator).

Preventative Maintenance Plan for French Island Generating Plant Units 3 & 4

French Island Generation Plant Preventative Maintenance Plan Description:

Gas Turbine inspection and maintenance at Xcel Energy is based on Original Equipment Manufacturers (OEM) recommendations and operating experience, coupled with sound engineering judgment. OEM guidance for frequency of inspection is based on starts and/or hours of operation dependent upon the frequency of operation of the gas turbines. For gas turbines that frequently start with low operating hours, maintenance and inspections are typically performed on a total number of starts basis. For gas turbines operating continuously for long periods of time with few starts, operating hours dictate the frequency of inspection and maintenance.

Xcel Energy's gas turbines are operated as peaking plants. That is, the units are only run during peak electricity demand conditions. These operating periods are typically in the 4 to 8 hour range. Consequently, Xcel Energy chooses to monitor the number of starts for a gas turbine as a means to determine proper maintenance and inspection intervals.

Operator Logs are maintained to document the number of starts for a gas turbine at each site. Xcel Energy personnel monitor the status of each gas turbine using the logs and determine the frequency of necessary maintenance for each gas turbine.

During operation of the gas turbines, operators periodically inspect the units, take readings and monitor for problems. These informal inspections provide for early detection of problems, mostly minor in severity, and allow for corrective action on an as needed basis.

Site Description:

Xcel Energy's French Island Generating Facility is a four unit facility consisting of two Refuse Derived Fuel (RDF) Units (#1 & #2) and two gas turbines (#3 & #4). The generating capacity of the two RDF units are less than 50 MW and are not required to be included in this preventive maintenance plan. The two gas turbine units have a winter Urge capacity of approximately 192 MW and a summer Urge capacity of approximately 154 MW.

The French Island facility has two Westinghouse 501 BB gas turbines. The maintenance and inspection requirements for these units are based on manufacturers recommendations for frequency and scope. Specific maintenance and inspection frequencies are listed in Table 1, the Maintenance Frequency Table on page 4.

Inspection Plan:

I. Gas Turbine Inspection

A. Maintenance and Inspection Activities

NOTE: All inspections are performed based on published Original Equipment Manufacturer (OEM) recommendations and inspection criteria, unit performance trends and engineering judgment.

1. Normal Operation – During normal operation, operators inspect the gas turbines for evidence of developing problems. Any identified problems are addressed appropriately. Routine maintenance items (e.g. filter replacement, oil replacement, etc.) are completed when indications warrant (e.g. filter differential pressure, oil sample test results, etc.) or at manufacturers recommended intervals.

2. Combustion Inspection – This activity involves removal and repair or replacement of fuel nozzles, combustion liners, transition pieces and crossfire tubes. While these components are removed from the gas turbine, accessible portions of the turbine can be visually inspected for indications of excessive wear.

3. Hot Gas Path Inspection – This inspection includes a complete combustion inspection (as described above) as well as the removal of the top half of the turbine case to allow for inspection of the turbine nozzle and turbine buckets.

4. Major Inspection – Inspection of all major components of the gas turbine that are subject to wear during normal turbine operation. This inspection includes such items as: turbine casings, shrouds, buckets, seals, diaphragms, compressor and air inlet. In addition the activities of the combustion inspection and the hot gas path inspection are also performed.

B. Maintenance Frequencies

1. Frequency of maintenance is determined by the number of starts. Machines that operate for short durations experience the most wear during start-up sequences when temperature fluctuations are the most severe and the stress of thermal cycling is most significant. See the Table below for the Original Equipment Manufacturer (OEM) recommended frequency of maintenance and inspection activities.

Maintenance Frequency*				
Manufacturer – Unit	Fuel Nozzle Inspection	Combustion Inspection	Hot Gas Path	Major Overhaul
Westinghouse 501BB	100 starts	300 starts	600 starts	1600 starts

Table 1

* Starts are defined as only those that are successful starts or fired aborts; in other words only those starts that actually introduce heat into the combustion section shall be counted as starts for the purpose of determine maintenance frequency.

2. Any indications of significant operating problems will be evaluated using sound engineering judgment. Maintenance work deemed necessary will be performed on an as needed basis, even if the maintenance will occur sooner than the recommended frequencies shown above.

3. The OEM recommended number of starts is strongly considered when determining maintenance intervals. Trending of operational performance and engineering judgment are also used when determining maintenance frequency. Therefore, maintenance inspection and outage frequency may differ from the OEM recommendations based on unit performance and engineering judgment.

II. Gas Turbine Rating

A. Operating performance, generator availability and reliability will be tracked via the National Electric Reliability Council (NERC) and Generator Availability Data System (GADS) requirements. Xcel Energy utilizes the MicroGads software as a database for handling this data. Individual unit data is reviewed periodically to determine adverse trends and identify generating units performing below acceptable levels.

III. Corrective Action Schedule

A. Table I of Section I details the manufacturers schedule for corrective action for their gas turbine. During the periodic inspections (i.e. combustion, hot gas, major) identified problems are corrected.

B. Budgeting – Annual budgets are developed based on operating histories. Each unit's current status compared to the inspection schedule identified in the Maintenance Frequency table is considered. Those units with impending inspections per the schedule are identified and funding is requested via the Xcel Energy budgeting process.

IV. Record Keeping

A. Maintenance records are maintained on-site of the inspection results for each gas turbine.

B. Generator availability data is tracked and entered on a monthly basis in the MicroGads system. This data is used to trend gas turbine performance and to budget for maintenance activities.

V. Outage Information Exchange

A. PSC-113.0607 requires utilities to share planned outage information for the coming year. This exchange of information will be facilitated through the local reliability councils and/or through participation in a regional transmission organization (RTO) such as the MISO (Midwest Independent System Operator).